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BIOLOGY OF THE IMMATURE STAGES OF *CHALYBION BENGALENSE* (DAHLBOM) (HYMENOPTERA : SPHECIDAE)

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(*Received* 6 *October* 1988)

Larva of *C. bengalense* feeds and develops on paralysed spiders provisioned in the nest by the mother wasp. Incubation period of egg is 36–56 h. There are three larval instars. Larval instars were determined based on the structure of the mandibles and the measurements of the first thoracic spiracle. During the months of October to February the prepupa undergoes diapause. Under normal conditions total developmental period from egg to adult is found to be 27.6 days. Mortality of immature stages by *Melittobia assemi* Dahms, *Chrysis* sp. and *Mutilla yerburyi* Cameron is reported.

(*Key words*: biology, *Chalybion bengalense*, sphecid wasp)

INTRODUCTION

Although various workers have contributed to the study of the behaviour of a number of species of aculeate wasps, scanty information is published on the biology of their immature stages. The present paper on the biology of the immature stages of *Chalybion bengalense* (Dahlbom) is based on part of a study conducted in Kerala during 1976–1979. This species is the only representative of the genus *Chalybion* in the Oriental region.

MATERIALS AND METHODS

Mud-nests provisioned and sealed by *C. bengalense* were collected. The contents were removed by breaking open the cell caps. Immature stages were observed right from the egg stage up to the emergence of the adult. Plastic boxes (6 cm × 5 cm × 1.5 cm) were used for rearing the immature stages. Each box was divided into four chambers (2 cm × 1.5 cm × 1.5 cm) using pieces of thermocol. Thus contents of four cells could be separately accommodated in one box and conveniently observed. The top of the box was provided with several holes for sufficient aeration.

Number of larval instars:

Because of the transparency of the cuticle it is very difficult to observe larval ecdysis. Also it is not uncommon for a larva to have more than one cuticle (including the cuticle of the previous moult) still partially covering it. Hence, the following characters are used in determining the larval instars- (1) the width and length of the larval head from dorsal side; (2) dentition of the mandibles (Fig. 1); (3) measurement of the first thoracic spiracle (because of the circular nature of the spiracle, an accurate measurement could be taken from any angle so long as the maximum diameter of the apparent elliptical outline was considered); (4) the length and width of the larval stages. Using this method three clearly defined instars are determined (Table 1).

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TABLE 1. Measurements of the immature stages of *Chalyobion bengalense*.

Description			Larval instars					
			I		II		III	
			A	B	A	B	A	B
Body	Length	(mm)	2.13	5.17	5.81	8.83	9.11	12.86
	Width	,,	0.73	1.41	1.51	1.93	2.16	3.20
			(n = 41)		(n = 50)		(n = 75)	
Head capsule	Length	,,	0.61	1.09	1.10	1.43	1.51	1.81
	Width	,,	0.63	0.99	1.01	1.19	1.23	1.61
			(n = 50)		(n = 45)		(n = 70)	
Mesothoracic spiracle	Diameter	,,	0.011	0.019	0.029	0.036	0.049	0.057
			(n = 50)		(n = 63)		(n = 80)	

n = number of observations; A = mean minimum; B = mean maximum.

OBSERVATIONS

As reported elsewhere, for the purpose of nesting the female wasp utilises cells of abandoned mud-nests of other sceliphronid or eumenid wasps or pre-existing holes. Each cell is provisioned with several paralysed spiders and a single egg is laid on the abdomen of one of the spiders during the course of provisioning. After hatching the young larva feeds on the body juice of the spider.

The egg:

The egg is hymenopteriform, approximately 2.3 mm in length and 0.67 mm in width. It is transluscent–white, cylindrical and slightly curved. The incubation period varies between 36–52 h ($\bar{X}$ = 42.7; n = 25).

First instar larva:

First instar larva superficially resembles the egg except for its segmentation. At this stage the larva injests only the body fluid of the host. Thirteen body segments are clearly visible in the late first instar larva. Lateral spiracles are present on all segments except on the mesothoracic one. Pleural lobes corresponding to each segment also becomes distinct, when the larva becomes completely free from the chorion. First instar larva remains and feeds on the same spot where the egg was positioned on the host body as it is incapable of shifting its position at this stage. By the time it finishes feeding on the first prey, the larva moults into second instar and shifts its position to another prey. The duration of the first instar larva varies between 48–60 h.

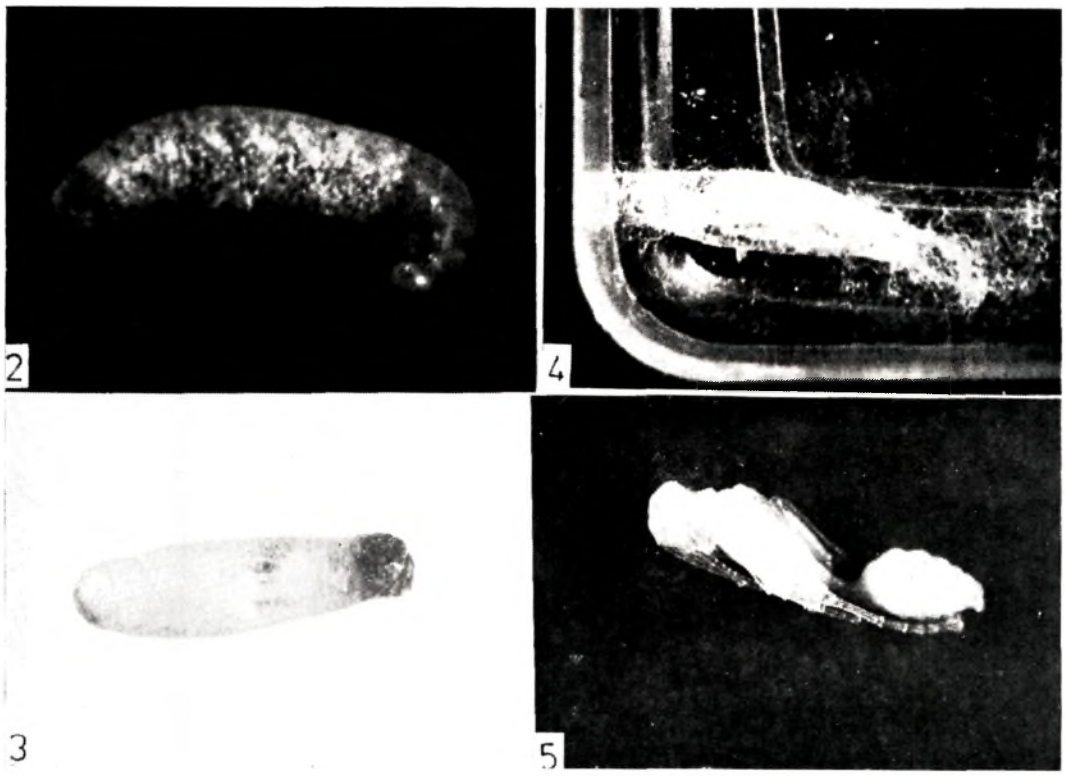
Second instar larva:

The duration of the second instar larva varies between 33–42 h. The pleural lobes in this stage are more distinct and convex in outline.

Third instar larva (Fig. 2):

Some changes in the mode of feeding of the larva from those of the previous instars can be noted at this stage. In addition to sucking the body fluid of the prey the hard parts are also consumed. The larval mandibles are sufficiently sclerotised to masticate the hard parts of the spiders. The larva

Fig. 1.



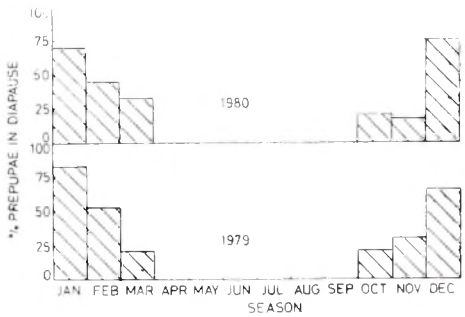


Fig. 6.

Fig. 1. Mandibular dentition of I-III larval instars; Fig. 2. Third instar larva; Fig. 3. Cocoon; Fig. 4. A cocoon under construction within a rearing box; Fig. 5. Pupa; Fig. 6. Season of diapause.

at this stage is found secreting at times a clear yellow fluid from the posterior end of the body. The duration of the third instar larva (up to the prepupal stage) varies between 80–99 h.

Cocoon (Fig. 3):

As soon as the larva stops feeding, it starts cocoon spinning. The larva first makes a loose mesh of silk extending inward from the sides of the cell. Extending its labio-maxillary complex well forward, the larva attaches the end of a thread to one side of the cell and turning its head attaches the thread to the other side and in this way a loose network is formed around the body. Remaining within this network, the larva then spins a cylindrical cocoon proper around its body. The network acts as a scaffolding for the building of the cocoon proper. Starting at the mid-region of its body, the larva constructs a close network around itself first on the ventral side, then by rotating formed a ring of closely woven thread (Fig. 4).

The ring is gradually enlarged until the anterior half of the body is completely enclosed. At this stage the larva turns on itself so as to face in reverse direction and then builds the other end of the cocoon. At the posterior end the cocoon is a chamber to revceive the larval faeces. The newly built cocoon is transluscent white in colour. Soon after its completion the larva applies a clear yellow fluid from its posterior end on to the wall of the cocoon which turns the cocoon papery and reddish-brown in colour. The faecal chamber remains white in colour as no fluid is applied on to it.

After spinning work is over, the larva remains within the cocoon with its posterior end directed towards the faecal chamber. Defaecation takes place 31–47 h after the commencement of cocoon spinning. The meconium is collected as a black fluid in the faecal chamber which later gets solidified. Cocoon is always found oriented with its anterior end directed to the cell cap. The length of male and female cocoon is found to be considerably varied. While the female cocoon measures an average of 14.6 mm (range 13.0–15.9 mm; $n=100$), the male cocoon measures only 11.9 mm (range 11.0–13.4 mm; $n = 100$). The male cocoon, though on an average distinctly smaller than females, is sometimes larger than the smallest females. Final instar larva after defaecation is found transformed to the prepupa. It is deep yellow in colour and slightly curved. Approximately 12 h prior to pupation, the prepupa straightens its body. The duration of prepupal stage varied within a range of 99–158 h depending on the weather. However, under conditions of diapause, the prepupal period is considerably longer.

Prepupal diapause:

C. bengalense prepupae are found undergoing diapause during the months from October to February the peak period being December and January (Fig. 6). The diapause period varies between 33–128 days.

Pupa (Fig. 5):

The pupa is exarate and at first yellowish-white in colour. It remains so for about 3–5 days and gradually turned brown and then black. The duration of pupal stage varies between 273–394 h.

Emergence:

When development is over, the wasp sheds the pupal exuvium. Before emergence from the cocoon, it excretes uric acid in the form of pellets. Later by strongly tilting its body the wasp breaks open the cocoon and comes out of it. After coming out of the cocoon it makes an exit hole on the cell cap. Before working on the cell cap

with one or two drops of metabolic water regurgitated on to it from mouth and removes pieces of mud out of it with the mandibles. Through the exit hole thus made the wasp emerges out.

Total development period:

Under normal conditions the duration of development from egg to adult varies from 24–34 days. However, during the diapause period it varies between 57–162 days.

Natural enemies:

Three parasitoid wasps, namely *Melittobia assemi* Dahms (Eulophidae), *Chrysis* sp. (Chrysididae) and *Mutilla yerburyi* Cameron (Mutillidae) were found to parasitise immature stages of *C. bengalense*. Of these *M. assemi* caused 30–50% prepupal mortality during diapause period. The number of parasite larvae developing on a single host prepupa varied between 54–320 (mean–157). Larva of *Chrysis* sp. developed on the food (spiders) stored for the host larva. In the case of *Mutilla yerburyi* the larva infested the prepupal stage of the host and on completion of development pupated within the host cocoon.

DISCUSSION

Detailed information is not available on the larval biology of any other *Chalybion* species to compare with that of *C. bengalense*. COVILLE *et al.* (1980) have observed that in *Trypoxylon tenoctitlan* Richard the incubation period is approximately two days. According to COWLEY (1962) the incubation period of *Pison spinolae* Shuckard is five to seven days. In *C. bengalense* it takes less than two days to hatch from the egg.

Much variation seems to exist in the case of the number of larval instars among sphecid wasps. While *Pison spinolae* has six larval instars (COWLEY, 1962) and *Solierella peckhami* (Ashmead) and *S. blaisdelli* (Bridwell) have two larval instars (CARILLO, 1962; CARILLO *et al.*, 1970), in the case of *C. bengalense* we have noted only two instars.

Defaecation in the form of white pellets by adult *Chalybion* before emergence from the cocoon has also been noticed in the case of *Sceliphron caementarium* (Drury) by SCHAFER (1949). According to him these white pellets are parts of the meconium collected due to metabolism of metamorphosis, though they are not passed until after emergence. The phenomenon of using the metabolic water for moistening the cell cap to make the exit hole on it (before emergence from the cell) is only known in *C. bengalense* among the various species of *Chalybion*.

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LABORATORY STUDIES ON THE HOST PLANT PREFERENCE OF *MANSONIA ANNULIFERA*, THE VECTOR OF BRUGIAN FILARIASIS

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(*Received* 12 *November* 1988)

Host plant selection for oviposition and immature survival of the Brugian filariasis vector *Mansonia annulifera* was studied in the laboratory by providing locally available aquatic weeds. Among all the weeds given, *Pistia stratiotes* the water lettuce was preferred for both oviposition and immature survival. The maximum survival rate observed was 85.6 ± 1.94 C. S. E., when reared on *P. stratites*. The developmental duration of immatures varied with different kinds of aquatic weeds.

(*Key words*: *Mansonia annulifera*, host plant preference)

INTRODUCTION

Mansonioides mosquitoes (Diptera: Culicidae) the vectors of Brugian filariasis (NAIR, 1962) were found to breed in aquatic habitats infested with weeds since immatures of *Mansonoides* are unable to obtain free oxygen from atmosphere and depend upon aquatic weeds for respiration (BURTON, 1959). The actual mechanism of attachment is an instinctive type of behaviour in the species (CHANDRASEKARAN, 1982). The behaviour, prevalence and distribution of *Mansonioides* mosquitoes have been influenced by ecological changes caused by the infiltration and establishment of different fast growing aquatic weeds in nature. To design and to develop a control strategy for them, knowledge on the host plant preference and host plant selection would be necessary. Hence a study was carried out to find out the effect of various host plants upon immatures of *Mansonioides* mosquitoes under laboratory condition and the results are presented.

MATERIALS AND METHODS

Aquatic weeds were collected from villages of Pondicherry and immatures of *Mansonioides* were obtained from the laboratory colony raised in VCRC.

To determine the host plant preference of *Mansonia annulifera* for ovipositing, different aquatic weeds viz., *Pistia stratiotes*, *Eichornia crassipes*, *Cyperus* sp., *Azolla* sp., *Spirodela polyrhiza*, *Marsilea quadrifolia*, *Lemna major* and *Mimosa pudiea* were exposed to 250-350 caged gravid females of *M. annulifera* in individual enamel bowl containing 200 ml of tap water. The water surfaces in all the bowls were uniformly covered with respective aquatic weeds. Next day all the ovitraps were removed and the egg clusters obtained were counted and recorded. An artificial medium, the thermocol pieces (1" × 1") were also tested. The experiment was replicated 5 times.

Investigations were also made to find out whether the aquatic weeds influence the

survival and developmental duration of immatures of *M. annulifera* under laboratory condition. One hundred freshly hatched larvae were introduced and reared in 2 plastic containers containing each of the aquatic weeds individually and 1.5 ml tap water. The water surface in all the container was covered with respective weeds. Each experiment was replicated 5 times. The larvae were fed every alternate day with 0.2 g of powdered yeast and dog biscuit. The entire study was carried out at controlled temperature (28±2°C).

RESULTS AND DISCUSSION

When oviposition preference of *M. annulifera* over different aquatic weeds was studied, maximum egg clusters were found to be deposited on the lower lamina of *P. stratiotes* (61.5%). It was also reported that in nature these mosquitoes show a general preference to ponds infested with *pistia* than any other weeds (IENGAR, 1938). The mean percentage of egg clusters seen in other weeds were 6.4 in *S. polyrhiza*, 2.6 in *Azolla* sp., 1.3 in each of *E. crassipes* and *L. major*. No egg cluster was seen in *Cyperus* sp., *M. quadrifolia* and *M. pudica*. Though these plants grow in shallow water bodies, occasionally support the breeding of *Mansonioides* mosquitoes (BURTON, 1959). However in thermocol sheet 26.6% of egg clusters were obtained.

The survival rate of immatures was greatly influenced by different host plants. The larvae grew, pupated and eclosed when reared on *P. stratiotes*, *E. crassipes*, *Ipomea* sp., *M. quadrifolia*, *M. pudica* and *L. major*. Of all the host plants tested maximum number of larvae surviving and eclosing to adult was seen in *P. stratiotes*. The maximum mean survival rate and eclosion rate observed were 85.6±1.94 (SE) and 83.4±2.11 (SE) respectively, when reared on *P. stratiotes*, which were followed by *E. crassipes*, *M. quadrifolia*, *Ipomea* sp., *M. pudica* and *L. major* (Table 1). During the larval rearing under laboratory condition *Pistia* plants were replaced with fresh ones every 5 day as they deteriorated the culture. Whereas, in *E. crassipes* and *M. quadrifolia* though the survival rate and eclosion rate were comparatively less when compared

TABLE 1. Immature survival and eclosion rate.

Host plant	Immature survival rate (%)	Eclosion rate (%)
P. stratiotes	85.6 ± 1.94 (SE)	83.4 ± 2.11 (SE)
E. crassipes	63.0 ± 2.34 (SE)	61.8 ± 2.35 (SE)
M. quadrifolia	42.8 ± 1.77 (SE)	28.8 ± 2.03 (SE)
Ipomea sp.	28.4 ± 1.08 (SE)	26.6 ± 1.72 (SE)
M. pudica	17.0 ± 1.51 (SE)	9.0 ± 1.22 (SE)
L. major	9.1 ± 2.57 (SE)	8.0 ± 2.79 (SE)
S. polyrhiza	—	—
Azolla sp.	—	—
Cyperus sp.	—	—
Thermocol	46.4 ± 1.43 (SE)	40.8 ± 1.56 (SE)

to that of *P. stratiotes*, these plants coexist with the immatures of *M. annulifera* till they emerge as adults. Though it was reported that the survival rate of *Mansonia* was higher in *Eichornia* plants than *Pistia* in the present study, maximum survival was seen with *Pistia* (RACHADA & SUPAT, 1988).

The developmental duration of immatures was not constant in all the host plants when exposed. The developmental duration from 1st instar to pupae was shortest when reared on *E. crassipes* (mean 26.5 days). The duration varied from 22–31, 24–35, 28–36, 28–37 and 29–42 days when reared on *P. stratiotes*, *Ipomea* sp., *M. quadrifolia* *M. pudica* and *L. major* respectively (Table 2). The variation in the developmental duration of immatures over different host plants presumes that the availability of arenchymatic tissues influences the metabolic activities. In plants which are poorly arenchymatic the respiration is being affected due to woody stem, which thereby delay the development (eg. *M. quadrifolia*, *M. pudica*, *L. major*) whereas other plants such as *E. crassipes*, *P. stratiotes* and *Ipomea* sp. are having highly arenchymatic tissues in stems and roots which facilitate the faster growth of *Mansonioides* larvae.

Total mortality of larvae had resulted when reared on *S. polyrhiza* and *Cyperus* sp., which indicates that the roots are hardy and woody and unsuitable for development. However when *Azolla* sp. was provided the larvae did not attach themselves to the very fine roots and they dye within 2-3 days. The death of immatures of *M.*

TABLE 2. Immature developmental duration (in days).

Host plant	Larval stages					Total duration
	I	II	III	IV	Pupa	
P. stratiotes	2–4 (2.7)	3–6 (4.1)	4–7 (4.8)	7–11 (8.9)	2–3 (2.1)	22–31 (27.5)
E. crassipes	2–4 (3.0)	3–5 (4.7)	4–6 (5.1)	6–10 (8.5)	2–3 (2.0)	22–28 (26.5)
Ipomea sp.	2–6 (4.8)	4–7 (6.1)	5–8 (6.8)	8–11 (10.1)	2–3 (2.1)	24–35 (31.5)
M. quadrifolia	3–6 (4.5)	4–8 (6.3)	4–9 (7.1)	7–14 (11.8)	2–4 (2.8)	28–36 (33.1)
M. pudica	3–6 (4.2)	5–7 (6.1)	5–8 (6.9)	8–14 (12.0)	2–3 (2.5)	28–37 (32.8)
L. major	3–8 (5.8)	5–8 (7.1)	6–10 (8.4)	10–14 (11.7)	2–4 (3.1)	29–42 (38.6)
S. polyrhiza	—	—	—	—	—	—
Azolla sp.	—	—	—	—	—	—
Cyperus sp.	—	—	—	—	—	—
Thermocol	2–5 (4.3)	3–7 (5.7)	5–8 (6.1)	7–11 (9.2)	2–3 (2.8)	23–34 (29.5)

Figures in parentheses refer to average days.

annulifera may be due to the toxic effect of *Azolla* sp., since it was reported that *Azolla* sp. has got toxic effect towards mosquito larvae (BECKING, 1978).

In the present study *M. annulifera* have oviposited readily in thermocol sheets. When the larvae were reared on the thermocol sheets the immature survival and eclosion rates observed were 46.4±1.43 (SE) and 40.8±1.56 (SE) respectively. However it needs further exploration whether it can be replaced with aquatic weeds in the laboratory colonies where the plants decay at short duration.

Since these mosquitoes have an obligatory association with selective hydrophytes (CHANDRASEKARAN, 1982) attention can be focussed towards the habitats which are highly infested with the weeds of choice in their control strategy. Also change in the behaviour pattern of these mosquitoes to various weeds due to ecological succession, further necessitates the need in studying the role of various aquatic weeds in influencing the vector density.

Hence the thorough knowledge on the behaviour pattern, immature survival and immature duration in relation with different weights will be highly beneficial in devising the control strategy of these vector mosquitoes for the control of Brugian filariasis.

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JUVENILE HORMONE INDUCED OVIPOSITION IN VIRGIN *TROGODERMA GRANARIUM* (DERMESTIDAE: COLEOPTERA)

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Various concentrations of juvenile hormone analogue (JHA) methoprene, administered to non-mated female *Trogoderma granarium* resulted in egg laying within 12-24 h. Virgin females responded each time to two separate administrations of the JHA one immediately after adult emergence and the second, on the fifth day, after the cessation of the first spell of oviposition. Adults derived from JHA treated pupae also laid eggs without mating. No egg laying was noticed in non-mated control females. The mechanism of action of juvenile hormone analogue in inducing egg laying by virgin females is not understood.

(*Key words:* *Trogoderma granarium*, oviposition, JH analogue, methoprene, oocytes)

INTRODUCTION

The control of oviposition by neurohormones is established in many insects (ENGELMANN, 1970; RUEGG *et al.*, 1981; RAABE, 1986). RAABE (1986) has cited that the brain and ventral nerve cord extracts could induce oviduct contraction in *Tenebrio*, *Carausius* and *Locusta*. In *Rhodnius*, an oviposition stimulation hormone is produced in the pars intercerebralis and this myotropic factor originates from ten cells (RAABE, 1986). RAABE (1986) has further stated that ecdysteroids trigger the production and release of neurohormones from the pars intercerebralis of *Rhodnius* and modulate uterus contractions in *Glossina*. ROBERT *et al.* (1986) have also found from *in vitro* studies that ecdysone initiates phasic uterus contraction or enhances the frequency of pre-existing contractile activity in *Glossina fuscipes*. In the mechanism of hormonal control of oviposition in these insects, RAABE (1986) rules out the possibility of juvenile hormone influencing oviposition and parturition. LOHER (1984) has reported that mating and filling of spermathecae is the stimulus for oviposition in *Acheta domesticus*. The spermathecae of *A. domesticus* are reported to contain PGE_2 and this stimulates virgin females to lay eggs.

STRAMBI (1986) has reported that allatectomy performed during the last instar suppressed ovipositional movements in *A. domesticus* which could be corrected by the injection of juvenile hormone. She also has suggested that the corpus allatum is indirectly responsible for ovipositional movements. This supports the earlier report of SLAMA *et al.* (1973) that allatectomized *Pyrrhocoris* oviposits when treated with juvenoids.

Trogoderma granarium females emerge with fully developed oocytes. Adults are short lived and do not feed. Mating and egg laying are completed within five days after emergence. Non-mated females do not lay eggs. Prolonged delay in mating results in the reduction of the number of eggs laid (KARNAVAR, 1972). The present study was initiated after the accidental observation of egg laying by non-mated adults derived from juvenile hormone analogue-treated pupae. Oviposition by non-mated adults treated with methoprene and

adults derived from methoprene treated pupae was observed, indicating a stimulatory effect of juvenile hormone on oviposition.

MATERIAL AND METHODS

Trogoderma granarium Everts (Dermestidae: Coleoptera) larvae were maintained on crushed wheat at 35 ± 1°C. Fifth instar larvae become motionless and enter into the pupal stage on the fourth day. In the first set of experiments, pupae of different age (30, 36, 42, and 84 h) were treated topically with juvenile hormone analogue (JHA), methoprene (ZR 515) obtained from Zoecon Corporation at different doses (0.02, 0.1, 0.2, and 0.5 μg/insect) in acetone. Treated pupae were allowed to metamorphose and the resulted adults were used for observing oviposition. In the second set, methoprene was administered to adults derived from normal pupae at zero h, one day, five days and ten days after emergence. Treated females were provided with oviposition sites (folded paper). In a third set of experiments, batches of newly emerged adults were given one dose of methoprene (0.1 or 0.2 μg/insect) and allowed to lay eggs. On the fifth day, the treatment was repeated and the animals were observed for oviposition till the tenth day. A minimum of 15 insects/batch were used in each set of experiments.

RESULTS AND DISCUSSION

Oviposition by virgin females derived from methoprene treated pupae:

All JHA treated pupae did not metamorphose into normal adults. Varying degrees of morphogenetic disorders were caused by methoprene. Based on the degree of malformation the resulted individuals were classified into six stages as reported by KARNAVAR (1973). Individuals in stages I-III looked more like the pupae, whereas stages IV-VI showed more pronounced adult characters. At the dose of 0.02 μg/pupa, all the four age groups of treated pupae yielded normal looking adults (30.77 to 90.91 %); whereas at 5μg/pupa, only the 84 h pupae developed into normal adults (72.72%). The ovarian response and the number of vitellogenic oocytes in such fully developed adults were also studied. The mean vitellogenic oocyte number of the normal adult was 72.4±5.35 and that of methoprene treated (0.5 μg/pupa) ones 67.0±8.51. Egg laying was induced by all doses of methoprene (Table 1). Compared to the adults treated with methoprene (Table 2), beetles derived from JHA treated pupae laid fewer eggs, in spite of having a mean of 67.0±8.51 fully developed oocytes in their ovaries. A psossible reason could be that the amount of JHA carried over to the adult stage through metamorphosis of the treated pupae was comparatively low.

Over the different age groups of pupae treated there was no significant difference among the mean number of eggs laid for doses 0.02 μg and 0.2 μg, whereas the difference was significant for 0.5 μg/insect.

Oviposition by methoprene treated virgin females:

Female beetles derived from normal pupae and subjcted to JHA treatment, started oviposition within 12 to 24 h of treatment. All the four doses used, induced egg laying (Table 2), the largest number being a mean of 67.2 ± 25.08. These were laid by adults treated with the highest dose used (0.5 μg/insect). On emergence, the normal adults had a mean of 72.4±5.35 vitellogenic oocytes. The number of eggs laid by the treated females on the whole increased with the dose of JHA administered (Table 2). This number did not correspond to the number

TABLE 1. Number of eggs laid (Mean ± SD) by virgin adults of *T. granarium* derived from methoprene treated pupae of different age.

Pupal age (h) at treatment	Dose of methoprene (μg/pupa)			
	0.02	0.1	0.2	0.5
30	nil (15)	" (15)	4.6 ± 3.91 (15)	4.4 ± 1.52 (15)
36	nil (15)	4.75 ± 3.20 (15)	1.3 ± 0.58 (15)	14.9 ± 10.93 (15)
42	nil (15)	11.14 ± 9.23 (15)	11.67 ± 9.98 (15)	5.3 ± 4.22 (15)
84	8.8 (range 1–20) (25)	10.6 ± 9.73 (25)	15.64 ± 10.60 (25)	15.7 ± 11.07 (25)
Control	0 (15)	0 (15)	0 (15)	0 (15)

Figures in parentheses indicate the number of insects used.

TABLE 2. Number of eggs laid (Mean±SD) by methoprene treated virgin *T. granarium* adults of different age.

Age after adult emergence	First dose (μg/insect)				Second dose (μg/insect)	
	0.02	0.1	0.2	0.5	0.1	0.2
0 h	14.91±6.61 (15)	52.3±24.43 (15)	23.6±11.15 (15)	67.2±25.08 (15)	No treatment & no egg laying	
1 day	16.0±9.81 (15)	29.38±11.29 (15)	15.1±11.57 (15)	26.0±10.24 (15)	"	"
5 days	9.67±6.74 (15)	17.9±9.50 (15)	22.6±7.39 (15)	20.26±13.36 (15)	"	"
10 days	11.4±9.17 (15)	16.8±10.20 (15)	11.5±6.53 (15)	23.6±12.78 (15)	" "	" "
*0 h		22.8±14.34 (25)			17.6±8.62 (25)	"
*0 h			24.9±11.18 (25)			20.4±8.45 (25)
Controls	0 (15)	0 (15)	0 (15)	0 (15)	0 (15)	0 (15)

Figures in parentheses indicate the number of insects used.
* Received two doses.

of vitellogenic oocytes present in the ovaries, suggesting that the dose of JHA administered was not sufficient to induce complete oviposition. To test this assumption, newly emerged adults were given one dose of JHA (0.1 or 0.2 μg/insect) and allowed to lay eggs (22.8$\pm$14.34 and 24.8$\pm$11.18 eggs, respectively). After the cessation of egg laying on the fifth day, the dose was repeated. This treatment induced the females to resume egg laying (17.6$\pm$8.62 and 20.4$\pm$8.45), suggesting that the initiation of oviposition was JHA dependent (Table 2). Comparable observation on the effect of second mating on continuation of oviposition and enhancement of the number of eggs laid was made in this insect by KARNAVAR (1972).

Proportion of eggs laid under methoprene treatment was significantly greater from that of control in all age groups of adults and in all doses used.

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STUDIES ON THE SUSCEPTIBILITY OF *HELIOTHIS ARMIGERA* HÜBNER (LEPIDOPTERA: NOCTUIDAE) TO THE ENTOMOPATHOGENIC FUNGUS *METARHIZIUM ANISOPLIAE* (METSCHNIKOFF) SOROKIN VAR. *ANISOPLIAE* TULLOCH

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Metarhizium anisopliae var. *anisopliae* **has been found to be pathogenic to larval instars, pre-pupae and pupae of** *Helioth.s armigera* **when it was tested at conidial suspension containing 1.8×10^9 conidia/ml by inflicting 80—100% mortality. None of the adults and eggs treated with conidial suspension showed any mortality. However, the eggs laid by the treated female were found to be sterile. The possible role of mycotoxin present in the culture filtrate, in inflicting high mortality to early instars, pre-pupae and pupae and the combined effect of toxin and conidial infection in later instars has also been discussed.**

(*Key words:* *Metarhizium anisopliae* var. *anisopliae*, *Heliothis armigera*, mycotoxin)

INTRODUCTION

The entomopathogenic fungus *Metarhizium anisopliae* var. *anisopliae* is known to attack over 200 species of insects covering seven orders. Among them, coleopterans are the most common hosts. *M. anisopliae* is the most widely used entomofungal pathogen in microbial control attempts (YENDOL & ROBERT, 1971). The possible role of this fungus in reducing pest populations has been considered by numerous investigators (LATCH, 1965; VEEN, 1968; ZACHARUK & TINLINE, 1968). Recently the occurrence of the virulent entomopathogenic fungus *M. anisopliae* Var. *anisopliae* has been reported from *Heliothis armigera* on tomato crop by GOPALAKRISHNAN & NARAYANAN (1988). In this paper the results obtained on further studies made on the host-pathogen relationship are reported and discussed.

MATERIALS AND METHODS

Preparation of conidial suspension:

The fungal conidial suspension used in this study was single spore isolated from cultures derived originally from diseased *H. armigera* larvae collected on tomato at Indian Institute of Horticultural Research Experimental Station at Hessaraghatta, Bangalore. The conidia were inoculated on to sorghum grains which were previously soaked in water for 24 h and autoclaved at 15 lb/cm^2 pressure for 30 min. The fungus grew well on the grains by producing white mycelial growth and sporulated profusely on eighth day after the inoculation. The fungus culture was thus maintained on sorghum grains continuously throughout the experiment under temperature 27°±2°C. The conidia were harvested using sterile distilled water

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containing 0.01% of Triton X-100. The stock suspension was made after filtration of the conidia through double layered muslin cloth. From the stock conidial suspension filtrate serial dilutions were made to obtain four concentrations, viz., 1.8×10^9, 1.8×10^8, 1.8×10^7 and 1.8×10^6 conidia/ml. The counting of conidia was done with the help of an improved Neubauer double ruled haemocytometer and phase contrast microscope at a magnification of 600×. The conidia harvested within 24 h were used for this experiment.

Source of host insect:

The larvae, pre-pupae, pupae, adults and eggs of *H. armigera* were obtained from the laboratory culture reared on a semisynthetic diet (NAGARKATTI & SATHYAPRAKASH, 1974) under sterile conditions. Disease free, larval instars were selected immedialtely after moulting, since the newly formed integument is highly susceptible to infection and conidial germination (FARGUES & VEY, 1974).

Method of inoculation:

All the stages of the insect, viz., different larval instars (I to V), pre-pupae, pupae, adults and eggs were used to conduct the study. About twenty larvae, pre-pupae, pupae and adults were inoculated per dose. In the case of eggs about 100 freshly laid fertile eggs were treated per dose. Each dose then was replicated three times. Diet surface treatment (GARCIA & IGNOFFO, 1978) and insect body surface contamination technique were adopted as method of inoculation.

The semi-synthetic diet for *H. armigera* was prepared, excluding formalin, in plastic containers (about one third) of size 4. 0 × 3.5 cm. The containers were provided with brass wire mesh lids to provide aeration. 0.1 ml conidial suspension was added to the diet containers and the surface was well contaminated with the help of glass rod. The larvae were just dipped in conidial suspension and placed on the contaminated diet. This was done to ensure contact of the conidia with the larval body, as this fungus grows only when it comes in contact with the integument. As the larvae were cannibalistic, they were kept individually in plastic containers.

The pre-pupae and pupae were just dipped in conidial suspension and placed on moist Whatman no. 41 filter paper in Petri-dishes of size 100 × 17 cm, five in each Petri–dish. Adults were allowed to swim in conidial suspension for a few seconds and then placed on a moist filter paper in sterile plastic container of size 12.5 × 10.0 cm, five adults in each container. The cotton swab dipped in 50% honey solution served as feed for the adults. In the case of eggs the egg cloth containing 100 eggs each was directly dipped in conidial suspension, shade dried and placed in plastic container (12.5 × 10.0 cm) containing moist filter paper. Sterile distilled water with 0.01% Triton X-100 served as control in all the cases. The whole experiment was carried out under laboratory condition where the temperature ranged between 27° ± 2°C. Observations were recorded daily for the mortality of larvae, pre-pupae, pupae, adults and eggs.

RESULTS AND DISCUSSION

Larval instars:

Results presented in Table I reveal that the fungus is highly pathogenic to all the five larval instars tested at 1.8×10^9 conidia/ml concentration by causing 80-100% mortality within 2-10 days period. However, the fungus at 1.8×10^8 and 1.8×10^9 conidia/ml concentrations could cause cent per cent mortality to the earlier (I and II) instars in 1–6 days period (Table 1). Thus,

TABLE 1. Effect of *Metarhizium anisopliae* var. *anisopliae* on different instars of *Heliothis armigera*.

Treatment	% Mortality														
	I Instar			II Instar			III Instar			IV Instar			V Instar		
	WOF	WF	Total	WOF	WF	Total	WOF	WF	Total	WOF	WF	Total	WOF	WF	Total
T_1: 1.8×10^9 spores/ml	85	15	100 (1–6)	25	75	100 (3–5)	35	55	90 (3–8)	55	45	100 (5–7)	55	25	80 (4–9)
T_2: 1.8×10^8 spores/ml	100	0	100 (3–6)	90	10	100 (3–5)	15	0	15 (3–5)	35	10	45 (5–12)	40	34	74 (4–9)
T_3: 1.8×10^7 spores/ml	85	0	85 (3–6)	50	5	55 (5)	10	0	10 (3)	45	15	60 (5–10)	30	20	50 (4–9)
T_4: 1.8×10^6 spores/ml	65	0	65 (3–8)	35	0	35 (6–8)	5	0	5 (5)	50	5	55 (5–10)	10	20	30 (6–13)
T_5: control	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Note : Figures in parentheses are incubation periods in days.

a : Mean of three replications.

WOF = without fungal growth.

WF = with fungal growth.

the neonate larva treated with all the four conidial concentrations showed mortality in 48 h after treatment. Such dead larvae while on examination under the microscope did not show either mycosis, bacteriosis or viriosis symptoms. Thus, the 100 and 75% of the mortality observed in the case of 1st and 2nd instars treated with 1.8×10^9 conidia/ml, within 48 h may be due to the toxin effect without showing any fungal growth.

Mortality due to fungal infection followed by sporulation was observed invariably in all the later instars (Table 1). The fungus infected larvae become hard and mummified and mycelial growth appeared between the body segments, on the spiracles, and on the appendages (Fig. 1). At the advanced stage, the entire body was covered with white mycelial growth leaving an appearance of white cottony cushion.

That the culture filtrate of *M. anisopliae* which contains toxins like destruxins A and B causing heavy mortality to the younger instars when compared to the grown up caterpillars has been demonstrated by SUZUKI *eta al.* (1971).

Histopathological studies of elaterid tissues infected by *M. anisopliae* suggest that toxins kill the host by inciting progressive degeneration of the host tissues due to the loss of structural integrity of membranes and then dehydration of cells by fluid loss (ZACHARUK, 1970). A strong toxaemic activity of *M. anisopliae* was demonstrated in invertebrates by laboratory tests using 3rd instar larvae of the scarabid *Oryctes rhinoceros* and final instar larvae of *Bombyx mori* as the test insects. The fact that toxic effects of the heamolymph of infected individuals are linked to the production of toxins viz., Destruxins A and B by the pathogen in living insects as observed by VEY *et al.* (1986) adds evidence to our findings.

The high percentage mortality observed in *H. armigera* with *M. anisopliae* var. *anisopliae* in the present study when compared to earlier report (URS & GOVINDU, 1971) may be due to the high susceptiblity of the just moulted larvae. since it has been observed that during ecdysis, hyphae and blastospores invade the exuvial fluid and infect the newly formed integument easily. Further, it has been observed that those insects which moult before the haemocoel is invaded may discard the fungus totally in the moulting process (FARGUES & VEY, 1974). It is also worth mentioning that at some stages the presence of bacteria in the haemocoel or in the cuticle does not permit the fungus to grow as it has been reported in the case of *Hylobius pales* by SCHABEL (1976).

Prepupae and pupae:

The prepupae and pupae showed 90% and 100% mortality in 4-11 and 2–7 days respectively, when they were tested at 1.8×10^9 conidia/ml concentration (Table 2). However, none of the prepupae treated with the last two concentrations showed any mortality.

It is evident from the result (Table 2) that the mycotoxin present in the culture filtrate not only affects the larval instars but also the prepupae and pupae. About 80 and 70% of the prepupae and puape respectively, inoculated with 1.8×10^9 conidia/ml died due to toxin effect without showing any fungal outgorwth. It has been reported that crude toxin obtained from *Fusarium aleyrodis* grown in Richard's liquid medium when applied topically on the larvae killed them (SINHA, 1974). Those prepupae treated with conidial suspension

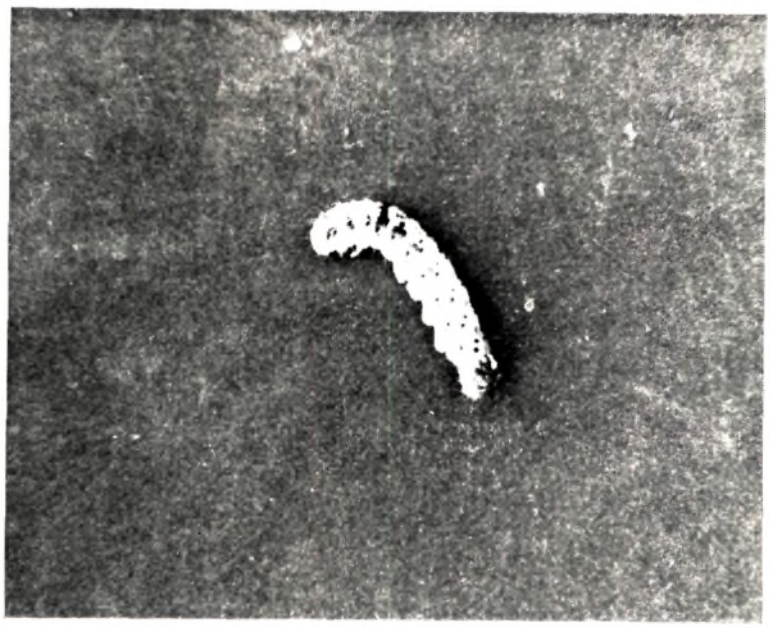

Fig. 1. Fungus-infected larva showing white mycelial growth between segments of the body and on appendages.

Fig. 2. Fungus-infected pre-pupa (extreme left) and pupae showing mycelial growth.

TABLE 2. Effect of *Metarhizium anisopliae* var. *anisopliae* on pre-pupa and pupa of *Heliothis armigera*.

Treatments	% Mortality[a]					
	Pre-pupae			Pupae		
	WOF	WF	Total	WOF	WF	Total
T_1 : 1.81×10^8 spores/ml	80	10	90 (4–11)	70	30	100 (2–7)
T_2 : 1.8×10^6 spores/ml	5	34	39 (4–12)	50	30	80 (3–7)
T_3 : 1.8×10^4 spores/ml	0	0	0	10	30	40 (3–8)
T_4 : 1.8×10^2 spores/ml	0	0	0	20	0	20 (3–7)
T_5 : control	0	0	0	0	0	0

Note: Figures in parentheses are incubation periods in days.
a = Mean of three replications.
WOF = without fungal growth.
WF = with fungal growth.

containing toxin turned black and body became somewhat tough. On dissection they revealed the presence of clumps of mycelium.

About 5% of the pre-pupae treated died during the course of development to pupal stage. Thus, the head and thoracic region remained in the pre-pupal stage, while the abdomen had undergone metamorphosis. About 10% of the inoculated pre-pupae had pupated and died due to fungal infection and ramification. The dead pupae thus became tough and hard and the white mycelial growth appeared in the region of spiracles and on the lateral segments of the pupae. Similar results were also obtained in case of pupae treated with the conidial suspension (Fig. 2).

It is obvious from the result that the pupae are more susceptible than the pre-pupae. This may be due to the fact that the prolonged pupal period of 8–9 days makes it more susceptible for infection, because of continuous contact with the conidia, than pre-pupa where it undergoes development in 24–78 h and during ecdysis it sheds off the conidia along with the skin and makes the pre-pupa less susceptible to infection. The observation that prolonged conidial contact with host cuticle stimulates conidial germination made by WALSTAD *et al.* (1970) supports these findings.

None of the adults and eggs treated with conidial suspension showed any mortality. The treated adults mated normally and the eggs laid by such adults were found sterile and did not hatch. The reason for this could not be explained. However, the eggs treated with the fungus hatched normally. The control in all the cases behaved in a normal way and there was no mortality.

Thus, it is evident from the result that the combined effect of toxin (in the culture filtrate) and conidial infection will play a major role in increasing the effectiveness of *M. anisopliae* var. *anisopliae* as the bio-control agent in controlling the gram pod borer *H. armigera*.

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RESIDUAL TOXICITY OF FOUR INSECTICIDES RECOMMENDED FOR CONTROL OF COCONUT COCCIDS ON THE PARASITOID FAUNA OF *OPISINA ARENOSELLA* WLK.

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Among the chemicals tested, fish oil rosin soap was found to be least toxic and its toxicity persisted up to 1 day for *Trichospilus pupivora*, 6 days for *Tetrastichus israeli*, and 2 days for *Eriborus trochanteratus* and *Bracon hebetor* respectively. Methomyl was toxic up to 7-13 days, dimethoate for 9-14 days and methyl-parathion was found to be highly toxic to the parasitic fauna of *Opisina arenosella*.

(*Key words: Opisina arenosella, Trichospilus pupivora, Tetrastichus israeli, Eriborus trochanteratus, Bracon hebetor*, P[-] idex, fish oil rosin soap)

INTRODUCTION

In coconut pest management, insecticides are used when the incidence of pests becomes very severe. Under such situations selective use of pesticides is absolutely necessary since biological control is invariably practised in coconut pest management. The modern synthetic insecticides are found to upset the balance of nature between the pests and their natural enemies and other associated organisms due to their broad spectrum of toxicity. The indirect effects of insecticides on natural enemies were reviewed by CROFT & BROWN (1975), and KIRITANI (1976). The selective use of pesticides in combination with biological control as an alternative to chemical control was suggested by RIPER (1944), BEIRNE (1962) and NEWSOM *et al.* (1976).

Though effective chemicals were applied for the control of coccids, they should not interfere with the parasitic fauna of *Opisina arenosella*, which are being released regularly in Tamil Nadu. Studies were made to find out the relative toxicity of pesticides on the parasites of *O. arenosella* viz., *Trichospilus pupivora* (NIRULA *et al.*, 1957; NAIR, 1964; CHANDRIKA & DAS 1972). *Tetrastichus israeli* (MANI & KURAN); *Bracon brevicornis* (MATHEW *et al.*, 1978) and *Eriborus trochanteratus* Morley (SWAMIAPPAN, 1984).

MATERIALS AND METHODS

The effect of chemicals evaluated for the control of coconut coccids such as dimethoate (0.03%), methomyl (0.025%), fish oil rosin soap (2.5%) and methyl parathion (0.05%) on the adult parasitoids was assessed. Each of the insecticides was sprayed on two and a half year old coconut seedlings raised in pots. For *Eriborus trochanteratus* three leaflets were collected from each seedling daily. The lower ends of the leaflets were kept dipped in water in a plastic container and covered by a mylar film tubular cage (70 × 8 cm). Ten freshly emerged adults of a mixed population of both male and female parasitoids were caged with honey as food inside and was replicated thrice. Twentyfour hours after introduction, mortality was assessed and continued till the mortality of the insects

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in the exposed leaflet reached zero level. For *Tetrastichus israeli, Trichospilus pupivora* and *Bracon hebetor*, leaflets were collected from sprayed palms at daily intervals. From each leaflet a 10 cm long piece was cut and kept in a glass tube (15 × 2 cm). Twenty numbers of one day old adults of *Trichospilus, Tetrastichus* and *Bracon* were introduced in each glass tube and then the open end was closed with muslin cloth. The parasites were provided with honey droplets as food. The mortality of the parasites 24 hours after exposure was recorded and continued till the mortality from the insects in the exposed leaflet reached zero. Persistent toxicity of the insecticides was determined in terms of PT index, calculated following the method of PRADHAN (1967) where P is the period for which toxicity persisted and T is the sum of corrected mortalities divided by the number of observations.

RESULTS AND DISCUSSION

The relative toxicity in the present investigation to *E. trochanteratus* (Table 1) was methyl parathion > methomyl > dimethoate > fish oil rosin soap and for *T. israeli* (Table 2), *T. pupivora* (Table 3) and *B. hebetor* (Table 4) it was methyl parathion > dimethoate > methomyl > fish oil rosin soap.

This study clearly indicates that fish oil rosin soap is least toxic to the parasitic fauna of *O. arenosella* at test concentration, where the toxicity persisted one to two days for *E. trochanteratus, T. pupivorus* and *B. hebetor* and six days in the case of *T. israeli*. Methomyl (not registered in India at present) was toxic to the parasitic fauna for 7–13 days. Even systemic insecticides such as dimethoate which disappear from treated plant materials at a fast rate due to absorption into the tissues, persists on coconut leaves at a level

TABLE 1. Corrected percentage mortality of adults *Eriborus trochanteratus* exposed to coconut leaves sprayed with insecticides and collected at various intervals after spraying.

Insecticides	Period after spraying (days)																P	T	PT Index	ORE
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16				
fish oil rosin soap (2.5%)	11.11	10.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	10.56	21.11	4
dimethoate (0.03%)	100	100	100	100	100	90	50	40	40	—	—	—	—	—	—	—	9	80.00	72.00	3
methomyl (0.025%)	100	100	100	100	100	100	100	100	80	70	30	—	—	—	—	—	11	89.06	979.99	2
methyl parathion (0.05%)	100	100	100	100	100	100	100	100	100	100	90	90	80	70	60	40	16	89.38	143.00	1

P = Period for which the toxicity persisted. T = Average residual toxicity. ORE = Order of relative efficacy.

TABLE 2. Corrected percentage mortality of adult *Tetrastichus israeli* exposed to coconut leaves sprayed with insecticides and collected at various intervals after spraying.

Insecticides	Period after spraying (days)															P	T	PT Index	ORE
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15				
fish oil rosin soap (2.5%)	100	100	85	75	50	15	—	—	—	—	—	—	—	—	—	6	70.83	425	4
dimethoate (0.03%)	100	100	100	100	100	100	100	100	80	80	75	75	35	20		14	83.21	1165	2
methomyl (0.025%)	100	100	90	80	75	75	50	35	35	25	25	25	20	—	—	13	56.54	725	3
methyl parathion (0.05%)	100	100	100	100	100	100	100	100	100	100	90	90	75	50	50	15	90.33	1355	1

P = Period for which the toxicity persisted. T = Average residual toxicity. ORE = Order of relative efficacy.

TABLE 3. Corrected percentage mortality of adult *Trichospilus pupivora* exposed to coconut leaves sprayed with insecticides and collected at various intervals after spraying.

Insecticides	Period after spraying (days)															P	T	PT Index	ORE
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15				
fish oil rosin soap (0.25)	100	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	100.00	100	4
dimethoate (0.03%)	100	100	100	100	100	100	100	100	65	60	40	25	—	—	—	12	82.50	990	2
methomyl (0.025%)	100	100	100	100	100	100	100	100	40	20	—	—	—	—	—	10	86.00	860	3
methyl parathion (0.05%)	100	100	100	100	100	100	100	100	100	90	75	50	50	50	—	14	86.78	1215	1

P = Period for which the toxicity persisted. T = Average residual toxicity. ORE = Order of relative persistence.

TABLE 4. Corrected percentage mortality of adult *Bracon hebetor* exposed to coconut leaves sprayed with insecticides and collected at various intervals after spraying.

Insecticides	Period after spraying (days)															P	T	PT Index	ORE
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15				
fish oil rosin soap (2.5%)	20	15	—	—	—	—	—	—	—	—	—	—	—	—	—	2	17.50	35	4
dimethoate (0.03%)	100	100	100	100	100	85	85	85	75	60	60	40	—	—	—	12	75.42	905	2
methomyl (0.025%)	85	75	65	65	50	40	40	—	—	—	—	—	—	—	—	7	60.00	420	3
methyl parathion (0.05%)	100	100	100	100	100	100	100	100	100	75	25	35	35	—	—	13	83.08	1080	1

P = Period for which the toxicity persisted. T = Average residual toxicity. ORE = Order of relative persistence.

toxic to the parasites for a period of 9–14 days after spraying. Methyl parathion was highly toxic to the parasites. CHANDRIKA & DAS (1972) reported that dimethoate peristed for 12 days and was toxic to *T. pupivora* which was similar to the present study. This study indicated that fish oil rosin soap can safely be included for the control of coccids and in the integrated pest management of leaf caterpillars as it does not have deleterious effects on the parasites of *O. arenosella* Wlk.

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CONTROL OF THE COCONUT SCALE *ASPIDIOTUS DESTRUCTOR* SIGN. IN THE NURSERY

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The coconut scale, *A. destructor* Sign., can be effectively controlled in the nursery with fish oil rosin soap at 2.5 per cent after three rounds of sprayings or methomyl 0.03 per cent or dimethoate 0.03 per cent or fish oil rosin soap 1.25 per cent or monocrotophos 0.04 per cent after four rounds of sprayings at weekly intervals which gave 100 per cent mortality of the scale insects.

(*Key words:* coconut scale, *Aspidiotus destructor*, control, fish oil rosin soap)

INTRODUCTION

Aspidiotus destructor Sign., the coconut scale insect of the family Diaspididae, is found practically in all the countries where coconut palms grow. Infested leaves first turn yellow and then dry up. The scale insect can attack the coconut at any age from germination at the nursery to the grown-up palm. According to the development of the coconut palm and the ecological conditions, the intensity of infestation can be variable and the control strategy also varies according to the age of the plant. Chemical treatments are easy to apply in the nursery or at an early age to prevent the further spread of the insect. Not much work has been done with regard to the control of coconut scale. Since it is assuming serious proportions, attempts were made to evaluate the chemicals which are generally effective against coccids in the nursery and the details are presented here.

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MATERIALS AND METHODS

An investigation was carried out at coconut farm of Tamil Nadu Agricultural University, Coimbatore with 15 seedlings of about 1–1½ years old per treatment. The treatments consist of monocroptophos 36 WSC (0.04%), dimethoate 30 EC (0.03%), methomyl 25 EC (0.025%), methyl-*o*-demeton 25 EC (0.025%), malathion 50 EC (0.1%), methyl parathion 50 EC (0.05%), phosphamidon 85 WSC (0.05%) and fish oil rosin soap (2.5 and 1.25%) replicated thrice in completely randomized design. The sprayings were given at weekly intervals for four consecutive weeks. The efficacy of insecticides was evaluated based on per cent mortality after each spraying and population density of the young scale insects. Observations were made by counting the total number of live and dead scale insects per cm^2 at five places each in five seedlings per treatment before and after spraying. The per cent mortality of scale insects and population density of the young scale insects due to the insecticides was recorded at two and six days after spraying.

RESULTS AND DISCUSSION

The percent mortality of scale insects observed two and six days after each spraying is shown in Tables 1 and 2. Result showed that percent mortalities of scale insects two days after spraying (Table 1) are much lower compared to six days after spraying (Table 2). Six days after the first to fourth sprayings there was still marked increase in percentage mortality in all treatments except for dimethoate (0.03%), methomyl (0.025%) and fish oil rosin soap (2.5%) which registered 94.6, 95.6, 98.1 percent mortality, respectively, after the second spraying. But, fish oil rosin soap at 1.25% concentration registered 98.4 percent mortality after the third spraying. After the fourth spraying 100 percent mortality was observed in monocrotophos (0.04%), dimethoate (0.03%), methomyl (0.025%), fish oil rosin soap at 1.25 and 2.5% respectively. Methyl parathion (0.05%) and phosphamidon (0.05%) registered 72.9 percent and 68.2 percent while methyl-*o*-demeton (0.025%), malathion (0.1%) had not satisfactorily controlled the scale insects even after the fourth spraying.

The population density of crawlers recorded at six days after each spraying (Table 3) clearly indicates that dimethoate (0.03%), methomyl (0.025%) and fish oil rosin soap were found to be effective in reducing the crawler density. After the second and third sprays with mono-

TABLE 1. Percent mortality of *A. destructor* Sign. two days after spraying.

Treatments	Number of sprayings			
	1st	2nd	3rd	4th
monocrotophos (0.04%)	19.06^{e} (25.81)	22.77^{b} (28.40)	58.14^{c} (45.92)	100.0^{e} (90.0)
dimethoate (0.03%)	33.41^{b} (35.28)	85.99^{e} (69.08)	97.68^{b} (83.05)	100.0^{e} (90.0)
methomyl (0.025%)	43.23^{g} (41.09)	96.05^{d} (81.14)	98.43^{b} (84.12)	100.0^{e} (90.0)
methyl-*o*-demeton (0.025%)	6.2^{b,c} (14.39)	16.15^{b} (23.66)	24.56^{b} (29.71)	37.62^{b} (37.78)
malathion (0.1%)	4.47^{b} (12.2)	21.37^{b} (27.52)	39.56^{b,c} (38.979)	56.37^{c} (48.70)
methyl parathion (0.05%)	9.40^{c,d} (17.85)	24.12^{b} (29.35)	54.73^{b,c} (47.75)	73.03^{d} (58.08)
phosphamidon (0.05%)	9.95^{d} (18.40)	28.04^{b} (31.96)	43.97^{c,d} (41.51)	57.70^{c} (59.49)
fish oil rosin soap (2.5%)	66.24^{h} (54.50)	98.13^{d} (83.44)	100.0^{f} (90.0)	100.0^{e} (90.0
fish oil rosin soap (1.25%)	40.66^{g} (39.58)	76.21^{e} (61.21)	98.25^{f} (82.38)	100.0^{e} (90.0)
control	0^{a}	0^{a}	0^{a}	0^{a}
SE	1.80	4.26	3.70	1.80
CD ($P=0.05$)	3.75	8.87	7.71	3.76

Transformed values in parentheses (Arcsine). In a column Means with the same letter are not significantly different at 5 percent level.

TABLE 2. Percent mortality of *A. destructor* Sign. six days after spraying

Treatments	Number of sprayings			
	1st	2nd	3rd	4th
monocrotophos (0.04%)	20.94^{e} (27.18)	24.81^{b} (29.88)	56.22^{e} (48.75)	100.0^{e} (90.0)
dimethoate (0.03%)	39.06^{d} (38.66)	94.61^{d} (79.28)	96.75^{d} (83.05)	100.0^{e} (90.0)
methomyl (0.025%)	63.12^{e} (52.66)	95.56^{d} (90.06)	98.43^{d} (84.12)	100.0^{e} (90.0)
methyl-*o*-demeton (0.025%)	21.44^{b} (14.51)	20.44^{b} (26.84)	22.61^{b} (34.80)	43.38^{b} (41.16)
malathion (0.1%)	22.38^{bc} (11.38)	21.5^{b} (27.15)	47.15^{c} (43.32)	58.56^{c} (49.99)
methyl parathion (0.05%)	11.38^{b} (19.71)	33.73^{b} (35.38)	58.47^{c} (49.92)	72.86^{d} (58.70)
phosphamidon (0.05%)	17.39^{bc} (24.59)	35.84^{b} (36.76)	58.38^{c} (49.92)	68.15^{d} (55.65)
fish oil rosin soap (2.5%)	78.58^{f} (62.63)	98.13^{d} (83.63)	100.0^{d} (90.0)	100.0^{e} (90.0)
fish oil rosin soap (1.25%)	63.58^{e} (53.0)	76.22 (61.21)	98.38^{d} (82.75)	100.0^{e} (90.0)
control	0^{a}	0^{a}	0^{a}	0^{a}
SE	2.59	4.83	4.14	1.83
CD ($P=0.05$)	5.59	10.04	8.61	3.82

Transformed values in parentheses (Arcsine). In a column Means with the same letter are not significantly different at 5 percent level.

crotophos (0.04%), methyl parathion (0.05%), phosphamidon (0.05%), methyl-*o*-demeton (0.025%) and malathion (0.1%) it was observed that there were new populations of crawlers present. However, after the fourth spraying, complete mortality of crawlers was obtained except in mehtyl-*o*-demeton (0.025%) and malathion (0.1%) treatments.

The results have amply indicated that insecticides, in order to be effective against scale insects, must be repeatedly applied. This is in conformity with the observations made by earlier workers (MARIAU & JULIA, 1977; ABAD & ELOJA, 1978; BACHMANN, 1976). Among insecticides, dimethoate is the effective chemical now available in the market since methomyl is not registered in India. Dimethoate is capable of giving good control of *A. destructor* Sign. and it should prove to be a valuable addition to the present rather restricted range of chemicals available against this pest.

Fish oil rosin soap, which gave spectacular control of this scale, can very well be utilized under field conditions. The mode of action of this oil is by asphyxiation since death occurs shortly after the appli-

TABLE 3. Population density of *A. destructor* Sign. crawlers six days after spraying.

Treatments	Number of sprayings			
	1st	2nd	3rd	4th
monocrotophos (0.04%)	0.00[a] (0.7071)	2.93[c] (1.8527)	3.00[b] (1.8708)	0.00[a] (0.7071
dimethoate (0.03%)	0.33[a] (0.8796)	0.00[a] (0.7071)	0.00[a] (0.7071)	0.0[a] (0.7071)
methomyl (0.025%)	0.00[a] (0.7071)	0.00[a] (0.7071)	0.00[a] (0.7071)	0.00[a] (0.7071)
methyl-*o*-demeton (0.025%)	2.67[b] (1.7742)	2.60[c] (.7589)	2.60[b] (1.75)	2.00[b] (1.5811)
malathion (0.1%)	3.00[b] (1.8708)	3.00[c] (1.8708)	1.00[a] (1.0950)	1.67[b] (1.3863)
methyl parathion (0.05%)	3.00[b] (1.8708)	1.33[b] (1.1709)	0.00[a] (0.7071)	0.00[a] (0.7071)
phosphamidon (0.05%)	2.67[b] (1.7742)	2.40[c] (1.6818)	0.60[a] (0.9769	0.00[a] (0.7071)
fish oil rosin soap (2.5%)	2.53[b] (1.7375)	0.00[a] (0.7071)	0.00[a] (0.7071)	0.00[a] (0.7071)
fish oil rosin soap (1.25%)	0.00[a] (0.7071)	0.00[a] (0.7071)	0.00[a] (0.7071)	00.0[a] 0.7071)
control	2.67[b] (1.7742)	3.00[c] (1.8708)	2.87[b] (1.8341)	3.00[c] (1.8708)
SE	0.1110	0.1395	0.2132	0.1130
CD ($P=0.05$)	0.2300	0.2900	0.4435	0.3599

Transformed values in parentheses (square root transformation) - $\sqrt{X+0.5}$. In a column, Means with the same letter are not significantly different at 5 percent level.

cation. Preliminary observations indicated that it also inhibits the settling of crawlers. At the test concentrations, phytotoxicity was not observed. Although the several generations of the coconut scale occurring throughout the year overlap considerably in their various stages, yet three to four sprays of low concentration directed against any stage of this pest are sufficient. Earlier workers have also reported that it is effective against the scale (BALASUBRAMANIAN *et al.*, 1979; SINGH & RAO, 1979). Studies on the toxicity to the parasites of *Opisina arenosella* Wlk. (author's unpublished data) indicates that it is relatively safe and it could be recommended for commercial spraying programmes as well as integrated pest management of the leaf caterpillars.

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PRELIMINARY INVESTIGATIONS ON CROSS INFECTION OF MICROSPORIDIAN SPORES FROM TASAR SILKWORM, *ANTHERAEA MYLITTA* DRUARY TO MULBERRY SILKWORM, *BOMBYX MORI* L.

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Preliminary investigations on the cross infection of microsporidian spores of tasar silkworm, *Antheraea mylitta* Druary to mulberry silkworm, *Bombyx mori* L. were conducted. Tasar microsporidians infected and caused disease in mulberry silkworm. The rate of infection and disease development varied in different ages if silkworms.

(*Key words:* microsporidian spores, cross infection, Tasar silkworm, *Antheraea mylitta*, mulberry silkworm, *Bombayx mori*)

INTRODUCTION

Infection of microsporidian spores (Nosema sp.) to tasar silkworm, *Antheraea mylitta* Druary is reported by JOLLY & SEN (1972). FUJIWARA (1980) and SATO *et al.* (1981) isolated besides *Nosema bombycis* Nagaeli, 4–6 other microsporidians belonging to *Nosema*, *Plestophora* and *Thelohania* genera from mulberry silkworm, *Bombyx mori* L. (Lepidoptera: Bombycidae). The infection of *N. bombycis* to 20 different lepidopteran insects is shown by MACHAY (1957). Similarly, KASHKAROVA (1981) reported the infection of *N. bombycis* to other 8 insects. From these reports, it is clear that microsporidians have a wide range of hosts. But SENGUPTA *et al.* (1981) reported the nonpathogenicity of *Nosema* spores of *A. mylitta* to eri silkworm, *Philosamia recini*. However, the studies are seldom on the cross infection of *Nosema* spores of *A. mylitta* to mulberry silkworm, *B. mori*. Hence, the preliminary study was initiated to determine whether *Nosema* spores of tasar silkworm will infect and cause disease to mulberry silkworm.

MATERIAL AND METHODS

Tasar silkworm, *A. mylitta* infected with microsporidian spores *Nosema* sp. were crushed with pestle and mortar in sterilised water. The solution was filtered through nylon bolting cloth (mesh 30 CD) to remove the tissues and debris. Then the spores were isolated and purified following the method described by CANTWELL (1974). Spores were suspended in sterilised distilled water and stored in refrigerator at 5°C. The freshly isolated spores were used for the study. Micrometer measurements for 100 fresh spores were noted down. Bivoltine silkworms of 'NB_{18}' race of different ages (just after I, II, III and IV moult) were fed on mulberry leaves smeared with pathogen suspension containing 10^7 spores/ml following the method suggested by MARTIGNONI & STEINHAUS (1961). The mulberry leaf smeared with distilled water was fed to the silkworms of control groups. The worms were reared on 'M_5' mulberry leaf till the end of the larval period. Four replications, 120 worms in each replication for II, III, IV instar batches and

100 worms for V instar batch were reared under identical conditions (temperature and humidity) both for control and treated batches. After 10 days of infection, 5 worms from each of replication of II, III, IV instar batches and after 6 days of infection from V instar batch were drawn and autopsied to test the presence of spores in different organs (tissues). Similarly, all dead worms during rearing and spinning were examined for the spores. Rate of infection and the extent of mortality has been noted down. Effective rate of rearing (ERR) both for treated and control batches were calculated as:

$$ERR = \frac{\text{No. of worms survied} \times 10.000}{\text{Initial no. of worms kept for rearing}}$$

RESULTS AND DISCUSSION

Nosema spores obtained from *A. mylitta* are bright, oval in shape. The size varied between 3.94 ± 0.34 μm in length, 1.92 ± 0.21 μm in breadth and the ratio between is 2.07 ± 0.24. These spores are slightly bigger in size compared to *N. bombycis* infecting mulberry silkworms. The size of *N. bombycis* is 3.34 ± 0.19 μm in length, 2.0 ± 0.23 μm breadth; length and breadth ratio is 1.7 ± 0.2.

TABLE 1. Rate of infection of Tasar microsporidian spores in different tissues of mulberry silkworm.

Tissues examined	Rate of infection in different tissues during							
	II instar		III instar		IV instar		V instar	
	worms	% infection	worms	% infection	worms	% infection	worms	% infection
Foregut	2+	10	7+ 8++	75	6+ 4++ 4+++	70	3+	15
Midgut	5+	25	9+ 7++ 4+++	100	9+ 6++ 3+++	90	3+	15
Hindgut	4+	20	4+ 5++ 2+++	55	6+ 5++ 1+++	60	3+	15
Fat bodies	3+	15	4+ 6++ 5+++	75	9+ 6++ 2+++	85	—	0
Silk gland	4+	20	1+ 4++ 4+++	45	9+ 2++ 2+++	65	—	0
Malphigian tubules	4+	20	1+ 8++ 3+++	60	10+ 3++ 1+++	70	1+	5

Note: 1, 2 No. indicate worms infected out of 20 worms examined.
+ = 0–30 spores per microcopic field.
++ = 31–100 ,, ,,
+++ = above 100 ,, ,,

Rate of infection of *Nosema* spores of tasar silkworms to mulberry silkworms is presented in Table 1. The rate of infection was lower in the batches infected during II and V instar worms. Worms infected during V instar, on examination of tissues on 6th day of infection for the presence of spores did not reveal the mature spores in fat bodies and silk-glands while spores were observed in the tissues of gut and Malpighian tubules (Table 1). This confirms the observation made by JOLLY (1986) that the mature spores appear only after 8th day of infection in fat bodies and silk gland tissues.

The effect of infection of spores to different ages of mulberry silkworms is shown in Table 2. The worms in the treated groups showed the symptoms of microsporidian disease like sluggishness, irregular in feeding and development and thereby increased number of undergrown worms, whereas such symptoms were not observed in the control batches. As the disease advanced, the mortality of worms increased. The maximum mortality was noticed during late age and spinning period. The drastic reduction in ERR was observed in the batches infected in III and IV instars and reared, showing that the III and IV age

TABLE 2. Effect of infection of tasar microsporidian spores to mulberry silkworm.

Age of worms		No. of worms per batch	Larval mortality due to			Cocoons harvested				ERR
			Tasar spores	Others Gra.	Others Fla.	Reelable	Melted	Flimsy	Total	
II	Treated	115	13.25 ±4.27	4.0 ±2.16	—	87.25 ±7.98	5.0 ±3.21	5.5 ±1.29	97.75 ±3.96	8500 (89)
	Control	115	—	3.0 ±0.7	2.0	101.5 ±3.53	2.5 ±0.7	5.7 ±0.7	109.5 ±0.7	9522 (100)
III	Treated	115	53.0 ±5.23	3.0 ±1.41	2.0 —	40.75 ±11.38	6.75 ±3.5	12.5 ±7.85	60.0 ±6.48	5217 (58)
	Control	115	—	10.0 ±1.41	—	92.75 ±2.42	6.5 ±4.9	5.5 ±0.7	104.0 ±2.84	9043 (100)
IV	Treated	115	82.0 ±6.97	3.5 ±0.7	2.5 ±0.7	15.5 ±8.38	7.0 ±2.44	7.25 ±2.87	29.75 ±9.0	2587 (27)
	Control	115	—	4.5 ±0.7	1.0 —	92.5 ±2.12	8.5 ±2.12	8.0 ±2.82	109.0 ±1.41	9478 (100)
	Treated	95	11.5 ±6.75	5.5 ±3.78	—	63.0 ±2.83	7.75 ±6.44	5.75 ±1.5	77.5 ±8.66	7947 (92)
	Control	95	—	4.5 ±3.53	7.0 ±4.24	70.5 ±0.7	8.0 ±2.82	3.5 ±0.7	82.0 ±2.83	8631 (100)

Note: ERR — Effective rate of rearing.
Figures in parenthses indicate index with respective control.

worms appears to be more susceptible to tasar microsporidian infection.

From this preliminary investigations, it is evident that the microsporidian (*Nosema* spores) of tasar silkworm also infect and cause disease in mulberry silkworms.

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A COMPARATIVE STUDY OF MOUNTING MATERIALS FOR SILKWORM *BOMBYX MORI* L.

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Five mounting materials, namely, grass cocoonages, plastic cocoonages, pinus shootlets, mustard hay and mulberry twigs, were tried for spinning of cocoons by ripe larvae of silkworm *Bombyx mori*. Out of these materials mustard hay, pinus shootlets and mulberry twigs, being locally available, were the cheapest. The cocoon features, i.e., larval mortality, yield of cocoons per 10,000 larvae (mounted) by weight, defective cocoons, and single cocoon weight *etc*. showed superiority under the treatment with mustard hay and pinus shotlets, being only next to grass and plastic cocoonages, which are costlier.

(*Key words:* silkworm, rearing, mounting materials, ripe larvae, pupae, rearers, cocoonages)

INTRODUCTION

An analysis of the cocoon crop data of silkworm, *Bombyx mori* clearly indicates that among the many factors that contribute for a good yield, the mounting material used for spinning of cocoons plays a vital role. In silkworm rearing where the economic product is cocoon, the mounting material besides affecting the yield and having a bearing on the quality of cocoon, must be economical (YOKOYAMA, 1962) and easily available (TANAKA, 1964). Moreover, the aim of the mounting material is to provide much cocooning place to ripe worms, and which needs less labour (ANONYMOUS, 1972). In fact the relative impact of rearing techniques of silkworm has been worked out for *B. mori* under tropical conditions in India (KRISHNASWAMI, 1978; KRISHNASWAMI *et al.*, 1978). But practically no information is available as to the effect of different mounting materials on the cocoon yield of silkworm under the temperate climatic conditions in the country. The present investigation was, therefore, undertaken to determine the feasibility of different materials for mounting of ripe silkworm larvae for spinning of cocoons in the temperate climatic belts of India.

MATERIALS AND METHODS

A hybrid silkworm, 'J_{122}' × 'Halauk', was reared in three rearing seasons, i.e., spring, summer and autumn, of Kashmir valley during 1986 as per the routine practices adopted at this Division (DAR *et al.*, 1988). The seed (eggs) of the hybrid is being supplied by Sericulture Development Deptt. of the state to the rearers. The three rearing seasons were spread over May–June, July–August, and September–October respectively. The rearing was conducted normally under temperature and relative humidity ranging from 23-27°C and 65–85% respectively up to the ripening of the mature worms. In seriposition the worms were mounted in five different mounting materials @ 200 worms per unit area of 6 sq. ft. replicated five times. The materials used were grass cocoonages (locally made from paddy grass), plastic cocoonages (imported from Japan), mustard hay, pinus shootlets and mulberry twigs (as control). The mulberry twigs are being used by the

rearers as material for spinning of cocoons by the silkworms in Kashmir. The temperature and humidity was maintained at 25°C and 65 ± 5% respectively throughout the six days period of seriposition.

Data on mortality percentage in seriposition, yield of cocoons per 10,000 larvae by number and by weight (kg), percentage of defective cocoons, survival rate of pupae, single cocoon weight (g), single shell weight (cg) and shell percentage was recorded and analysed statistically. The average single cocoon, shell weight and shell percentage was calculated by random sampling of normal and good sized cocoons (ten males and ten females) for each replication.

RESULTS AND DISCUSSION

The data recorded was analysed and tabulated (Table 1). The table reveals that mortality in seriposition was significant in autumn, where lower mortality was obtained in treatments with plastic and grass cocoonages under the treatments better results were obtained in summer and spring too.

The yield of cocoons per 10,000 larvae (mounted) by weight was non-significant in all the three seasons; yet a better yield was recorded for grass cocoonages in spring and autumn, and for mustard hay in summer.

In spring the yield of cocoons per 10,000 larvae by number was significant and was the highest under treatment with plastic cocoonages, followed by grass cocoonages and mustard hay. The better results were again recorded under plastic cocoonages in summer and autumn.

The percentage of defective cocoons was significantly low under plastic cocoonages alone in spring and being followed by grass cocoonages. In summer and autumn the better results were recorded in grass cocoonages.

There was no statistical difference amongst various mounting materials for survival rate of pupae in any rearing season, although a higher rate was recorded for grass cocoonages in spring and autumn, and pinus shootlets in summer.

No statistical differences for single cocoons weight, shell weight and shell percentage was observed in any season for any material. However, a better cocoon weight was recorded for the treatment with grass cocoonages in spring and autumn and for mustard hay in summer. The shell weight was slightly superior under the treatment with grass cocoonages in spring, and in mustard hay in summer and autumn. The average shell percentage was better under the treatments with mulberry twigs, pinus shootlets and mustard hay in spring, summer and autumn respectively. However, the average percentage of defective cocoons was on the higher ebb under the treatment with mulberry twigs; as such the cocoons become unreelable.

Further, to study the interaction of the materials with different rearing seasons, the data recorded for all these parameters, was analysed for variance (Table 2). From the table it is clear that the interaction season × material was non-significant for all the characters except the mortality of worms in seriposition. The variance due to seasons was highly significant for all the parameters. The variance due to materials (treatments) was significant for mortality, yield of cocoons for 10,000 larvae by weight, defective cocoons, single cocoon weight and shell percentage.

In conclusion, the inference can be drawn from the studies conducted, that the mounting materials like grass and plastic cocoonage have decidedly a better impact on cocoon features, but keeping in view the cost factor,

TABLE 1. Influence of mounting material on cocoon features of *Bombyx mori*.

Parameter	Season	Treatments					CD 5%
		Grass cocoon-ages	Plastic cocoon-ages	Pinus shoot lets	Mustard hay	Mulberry twings (control)	
Mortality in seriposition (%)	Spring	0.01	0.20	0.20	0.30	0.20	NS
	Summer	2.4	1.4	1.5	2.0	1.8	NS
	Autumn	2.6	1.2	4.8	3.6	4.2	2.08
Yield/10,000 larvae by wt (kg)	Spring	23.590	22.880	21.900	23.420	22.640	NS
	Summer	18.320	18.260	18.070	18.770	18.430	NS
	Autumn	14.070	13.750	12.830	13.430	13.400	NS
Yield/10,000 larvae by no.	Spring	9910	9930	9630	9570	9060	209
	Summer	9660	9870	9842	9800	9810	NS
	Autumn	9510	9560	9020	9350	9100	NS
Percentage of defective cocoons	Spring	3.80	2.64	7.37	4.86	6.72	2.94
	Summer	5.11	5.18	6.93	5.20	8.66	NS
	Autumn	5.61	6.09	8.53	6.96	8.09	NS
Survival rate of pupae	Spring	99.89	99.79	99.76	99.67	99.76	NS
	Summer	96.57	57.86	99.59	98.67	99.38	NS
	Autumn	97.16	96.64	95.30	94.56	96.52	NS
Single cocoon wt (g)	Spring	2.23	2.15	2.13	2.13	2.14	NS
	Summer	1.72	1.71	1.71	1.77	1.75	NS
	Autumn	1.37	1.34	1.30	1.33	1.32	NS
Single shell weight (cg)	Spring	42.2	39.7	40.5	40.7	41.4	NS
	Summer	31.8	31.5	32.1	33.1	32.3	NS
	Autumn	23.7	24.0	23.3	24.2	23.3	NS
Shell percentage	Spring	19.19	18.68	19.55	19.44	19.66	NS
	Summer	18.75	18.60	19.08	18.92	18.66	NS
	Autumn	17.60	18.01	18.12	18.37	17.81	NS

TABLE 2. Mean squares of some economic features of cocoons of *Bombyx mori* L.

Source of variation	df	Mortality in seri-position	Yield of cocoons per 10,000 larvae mounted		Defective cocoons (%)	Survival rate of pupae	Single cocoon wt (g)	Single shell wt (cg)	Shell percentage
			by wt (g)	by no.					
Replications	4	1.35NS	7.82*	0.84NS	0.55NS	0.45NS	6.00*	1.16NS	05.2NS
Seasons	2	47.15***	712.72***	16.65**	6.00*	12.54**	1220.00***	1195.77***	20.08**
Materials	4	3.07*	3.21*	0.15NS	7.98*	0.95NS	3.50*	1.44NS	3.38*
Seasons × Materials	8	2.75*	0.72NS	0.43NS	0.79NS	0.14NS	1.50NS	1.56NS	0.19NS
Error	56	1.26	0.76	0.26	4.06	7.14	0.15	1.54	0.36
CD 1%		2.47	1.95	1.12	4.43	29.40	0.20	2.73	1.32
CD 5%		1.42	1.10	0.64	2.55	16.90	0.12	1.56	0.76

NS .. Nonsignificant.
* .. Significant.
** .. More significant.
*** .. Highly significant.

the same cannot be afforded by the poor rearers of the valley. On the other hand, the mounting materials like mustard hay, pinus shootlets and mulberry twigs are easily available throughout the state. In treatments like mustard hay and pinus shootlets, the cocoon features were quite superior, being next only to plastic and grass cocoonages.

Keeping in view all the factors such as easy availability, economics and easy handling (ANONYMOUS, 1972), the use of mustard hay and pinus shootlets as the seriposition material for the silkworm larvae is feasible and suggestive under the climatic conditions of Kashmir in particular and temperate climatic belts of India in general.

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CAN TROPICAL TASAR SILKWORM *ANTHERAEA PAPHIA* (LINN.) BE REARED INDOORS?

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Antheraea paphia (Linn.) is a wild type of silkworm. Its outdoor cultivation suffers great losses due to depredation by natural enemies and changes in climatic conditions. Moreover, measures to improve the quality of silk by selective breeding are improbable by the outdoor cultivation methods. Therefore, an attempt was made to rear the silkworm, indoors. Detailed procedures are described, and the techniques are compared with those adopted for the other species.

In one annual cycle, three generations were maintained in the indoor conditions, and in each generation earlier 3 instars were reared in box rearing and the later 2 by open cut shoot method. Mounting of worms on Chandrikes for spinning the cocoons was found more suitable. The biology and behaviour of various life stages for one annual cycle were recorded, and the effect of indoor rearing on cocoon characters are analysed by comparing the cocoon characters of the indoor generations with those of the outdoor one. Feasibilities for indoor rearing are discussed.

(*Key words:* Tropical tasar silkworm, *Antheraea paphia*, indoor rearing, box rearing, cut shoot rearing, mountage)

INTRODUCTION

The tropical tasar silkworm *Antheraea paphia* (Linn.) (=*Antheraea mylitta* Drury) (ARORA & GUPTA, 1979), is a typical wild form which occurs in a distinct belt of humid and dense tropical forests of the central and southern plateau (JOLLY *et al.*, 1974). It is being cultivated outdoors, on commercial scale, in the states of Bihar, Madhya Pradesh, Karnataka, Maharashtra, Andhra Pradesh, Orissa and West Bengal. Being a polyphagous insect it feeds on the naturally grown forest plantations of sal (*Shorea robusta*), ber (*Zizyphus jujuba*), jamun (*Eugenia jambolana*), asan (*Terminalia tomentosa*), country almond (*T. catappa*) etc. (FLETCHER, 1914; LEFROY, 1916). For commercial cultivation, however, only sal and asan plantations are employed. Tasar cultivation is flourishing in India, and India stands second in the world tasar silk production (SENGUPTA, 1986).

Returns from the presently practised outdoor cultivation are extremely low, and only 20–30% of the larvae released in the forest produce cocoons (JOLLY *et al.*, 1974). The changing climatic conditions, parasites, pathogens and predators are the causes for the low yield. Moreover, the moths breed at random, and therefore, no measures can be imposed for the production of improved quality silk. Thus BEESON (1941) emphasized the need to protect the caterpillars from natural enemies and, prohibit the moths from random mating. Therefore, the present studies were undertaken to note whether the silkworm *A. paphia* can be reared indoors, as a primary step towards achieving the latter goal.

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FLETCHER (1914) opined that the moths fail to pair in confinement and the silkworm cannot be reared indoors on commercial scale. However, our ealier work (PATIL & SAVANURMATH, 1988) has suggested that indoor breeding in *A. paphia* can be successful. Moreover, LEFROY (1916) reported that Capt. Coussmakar from Poona was able to breed tasar moths under semidomesticated conditions, and the brooded (bivoltine) race which was maintained on ber was successfully reared under captivity at Pusa. However, these two methods of rearing proved to be commercially nonviable. Indoor rearing of the silkworm, *A. mylitta* up to first moult, was standardized at Ranchi, and different methods of indoor spinning of the cocoons were tried. Further, the indoor rearing techniques for oak tasar silkworm *A. proylei* were also standardized in Western Himalayan region (JOLLY *et al.*, 1974). Recently, KURIBAYASHI (1981) was successful in rearing the Japanese oak tasar silkworm *A. yamamai*, indoors. Furthermore, THANGAVELU & SAHU (1983, 1988) hvae repored the successful indoor rearing of the muga silkworm *A. assama*. However, detailed and critical information about the indoor maintenance of *A. paphia* is not available, and therefore, the present studies have been undertaken.

MATERIAL AND METHODS

The tasar cocoons, collected from Hesaraghatta forest (Bangalore District) during the second week of June, 1986 were maintained in the laboratory for moth emergence and the indoor mating. The moths were identified as *Antheraea paphia* (Linn.). About 1250 eggs from 5 layings, prepared from the indoor mating of the moths (PATIL & SAVANURMATH, 1988), were incubated in the laboratory conditions, in open Petri-dishes. Emerged young larvae were reared in captivity as per the procedures described below. As many as 3 generations were maintained on *T. tomentosa* leaves during the period from July 1986 to February 1987 under Bangalore (12°58' north latitude 77°35' east longitude and 930 meter mean-sea-level) conditions. This place is situated in south-eastern dry zone of Karnataka and has a semiarid climate. The mean minimum and maximum temperatures are 13.3°C in January and 34.6°C in May, respectively. The annual rainfal is around 798.7 mm with two peaks one in June (153.00 mm) and another in September (338.6 mm).

The experiments were conducted both in indoor and outdoor conditions, representing the commercial method of culturing, though on a smaller scale. The mean minimum and maximum temperature, and the mean relative humidity of the laboratory where the indoor experiments were conducted were recorded for each rearing. The data on economic cocoon parameters of different rearings was recorded and analyzed statistically by applying Student's "t" test.

1. *Indoor box rearing:*

The early age larvae (first three instars) were very active and highly migratory. They require relatively less space and higher temperature (28-30°C) and relative humidity (75–85%) for proper rearing (JOLLY *et al.*, 1974). Therefore, they were placed in plastic bottles (height 27 cm; diameter 11cm) with tender leaves (Fig. 1). The cut tender shoots were wrapped with wet cotton at the cut end to avoid withering of leaves (Fig. 2). The leaves were put gently over the just-hatched larvae and, the larvae attached to the leaves were either ransferred into the bottles along with the leaves or were brushed into the bottles with the help of bird feathers. Bottles were closed with thin muslin cloth, which helped to retain the worms inside the bottle and to provide aeration. Bottles were changed daily to the cleaned and sterilized (with 2% formal-

Figs: 1. Indoor rearing in plastic bottles; 2. Cut tender leaves of *Terminalia* wrapped with wet cotton showing the newly hatched worms feeding on the leaves; 3. Indoor cut shoot rearing in round bamboo trays; 4. Bamboo trays arranged in shelves on wooden rearing stand; 5. Cocoons constructed in dried leaves and shoots of *Terminalia*; 6. The matured worms being released on bamboo Chandrike for spinning cocoons; 7. Cocoons constructed between the *Terminalia* leaves; 8. Cocoons constructed on bamboo Chandrike.

dehyde) ones, and fresh leaves were supplied twice a day. Worms settled for moult were not disturbed by feeding or cleaning the bed. However, the bottles were kept open during the moulting period.

2. *Indoor cut shoot rearing:*

The late age (4th and 5th instar larvae) were relatively less migratory and more voracious. They required more space, good aeration, less warmth (26-28°C) and humidity (60–70%, JOLLY *et al.*, 1974). Therefore the method of rearing on cut shoots, in open trays (Fig. 3), was found to be very convenient. Round bamboo trays, arranged on shelves on wooden rearing stands (Fig. 4), were employed for the purpose. The shoots were harvested twice a day, and food was replenished four times a day. The rearing beds were cleaned every day in the morning. However, during the moulting period neither the food was supplied nor the beds were cleaned. The individual rearing trays were covered with nylon nets. This method helped to retain the worms inside the rearing trays, as well as, protected the worms from the attack ofthe parasitoid like Uzi (Uji) fly and other predators.

Different mountages for indoor spinning of cocoons were tried. The biology and behaviour of various life stages, for different seasons of one annual cycle were also recorded.

OBSERVATION AND DISCUSSION

It was observed that the tasar silkworm *A. paphia* could be reared indoors and it can be maintained successfully in the laboratory up to three generations. The incubation period for eggs, larval and pupal durations, and the total span of life-cycles for all the three generations, along with the relevant temperature and relative humidity maintained in the laboratory for the respective generations, are presented in Table 1. It was observed that the rhythms for feeding, spinning, and moth emergence among the individuals of a batch, were slightly disturbed. Such variations are always expected when organisms are reared under conditions other than their natural environment. It was also evident that the life stages of the third generation were very much prolonged, possibly due to the seasonal changes. Unduly prolonged pupal stage of the third generation, which synchronised with that of the wild types, possibly indicated the inclusion of the summer pupal diapause. However, the moths which emerged after completing the diapause, could not synchronise their time of emergence. As a result adequate number of fertilized eggs were not produced to continue the indoor rearing for the second year. Therefore, the biology and behaviour of the life-stages, and the cocoon characters of only the three available generations are described below.

Incubation period for eggs:

Incubation period for eggs utilized for first gneration (July-September, 1986) was shorter (10–11 days) as compared with that for the second (September-November, 1986: 11–12 days) or the third generation (November 1986–February, 1987 : 14–15 days) (Table 1). Perhaps the uncontrolled laboratory conditions of temperature and humidity, which varied from season to season, were responsible for the variation. KURIBAYASHI (1981) has reported 6-10 days incubation for *A. yamamai* eggs.

Larval period:

Larval period, as well, was shorter in first generation (27–29 days) than in the second (28–30 days) or the third (42-48 days) generation (Table 1). However JOLLY *et al.* (1974) recorded respectively 30-35, 40-45 and 60-70 days larval period for *A. mylitta*, whereas, KURIBAYASHI (1981) accounted 34-40 days larval period for *A. yamamai*.

TABLE 1. Seasonal variations in duration of the life-stages of *A. paphia* under indoor maintenance.

Generations (periods)	Temperature (Mean °C)		Relative humidity (Mean, %)	Incubation period for eggs (days)	Larval duration (days)	Pupal duration (days)	Life-span Total duration) (days)
	Minimum	Maximum					
July — September, 1986	23.88	24.85	83.73	11.00 (10–11)	28.00 (27–29)	29.71 (27–34)	68.71 (64–74)
September — November 1986	24.39	25.40	79.62	11.61 (11–12)	29.00 (28.30)	32.80 (28.39)	79.41 (67.81)
November, 1986 — February, 1987	23.34	24.33	63.32	14.00 (14–15)	44.30 (42–48)	94.30 (91–98)	152.60 (147–161)

Larval behaviour:

The larvae of all ages were very sensitive to physical disturbances, especially during moulting period. Shaking or touching stopped them from feeding, leading to the contraction of the body as a protective device. Grown up larvae fed on leaves starting from the margin towards midrib, holding fast the supports other than the leaf lamina. But, young larvae fed in either directions resting on the leaf lamina. The larvae could hardly be detached from their hold because of their strong grasp. This nature posed problems in cleaning the bed during indoor rearing. Although the IV and V instar worms were relatively less active, the ripened worms appeared to be quite capable of moving long distances during the prespinning period.

Moulting:

The silkworm retained its tetramoulter nature even under indoor conditions. There were five distinct instars. The larvae settled for moulting remained motionless, with their darkened head kept bent vertically downwards at the prothoracic region, without feeding for 1-2 days. It shed its head capsule first, and then pushed forward through its old skin. Sometimes the head capsule remained attached to the exuvium. Freshly moulted larva was soft and pale coloured with a bigger head, often eating its own cast skin. The larvae resumed feeding after a gap of an hour.

During the intermoult periods the larvae grew to their maximum size. The fully matured larvae weighed, on an average, 10.3 g with the maximum of 15.26 g.

Cocoon spinning:

At the end of fifth instar, the matured worms stopped feeding, shrank in length and turned light green in colour by evacuating from their alimentary canal a green semisolid faecal matter. After a short rest, they started moving vigourously in search of a suitable place for spinning the cocoons. They constructed both nonpedunculate and pedunculate cocoons. But the pedunculate ones prepondered. The cocoons were ash and light yellow in colour. Details of the cocoon characters will be dealt separately.

Pupal period:

The pupal period also varied widely; first generation: 27-34 days, second: 28-39 daysand the third generaion: 91-98 days (Table 1). Inordiate prolongation of the pupal period during the third generation was obviously because of the inclusion of the summer pupal

diapause in the life-cycle. JOLLY *et al.* (1974) have recorded a 4-month pupal-diapause (February-May) in *A. mylitta*, and KURIBAYASHI (1981) has mentioned about the pupal diapause in *A. yamamai*.

Life-span:

Egg to egg-stage duration for the life-cycles of different generations, also presented a wide range of variation. For instance, first generation ranged between 64–74, second generation 67-81, and the third generation varied between 147-161 days (Table1). Changing climatic conditions influencing the microenvironment of the laboratory, possible seasonal changes in the food plants, and the genetical factors influencing the neuroendocrinological conditions of the generations might have been responsible for the variations.

Effect of indoor rearing on cocoon characters:

Comparisons of the commercial cocoon characters among the three indoor generations, as well as, with those of the outdoor generation, are shown in Tables 2 and 3. It was observed that the cocoon formation among the individuals of the same generation

Table 2. Effect of indoor rearing on cocoon characters of *A. paphia*.

Number of observations	Cocoon length (cm)				Cocoon circumference (cm)			
	A	B	C	D	A	B	C	D
1	4.1	4.1	5.2	4.5	7.5	6.2	7.9	6.7
2	4.5	5.4	4.8	4.5	7.7	7.4	8.0	6.6
3	4.0	4.1	5.3	5.6	7.1	6.4	7.5	7.5
4	4.2	5.3	4.1	4.3	7.3	7.6	7.2	6.3
5	4.0	5.5	4.8	4.6	7.2	7.5	7.6	7.2
6	4.3	5.6	4.9	4.9	7.4	7.6	7.6	8.0
7	4.7	4.6	4.2	4.2	8.0	6.6	7.0	6.7
8	4.5	4.5	4.3	4.6	7.1	6.8	7.2	6.5
9	4.3	4.3	4.2	3.9	7.2	6.4	7.3	6.4
10	4.8	4.6	4.6	4.3	7.5	7.1	6.6	6.5
Mean	4.34	4.80	4.64	4.54	7.40	6.96	7.39	6.84

	For comparison of:						For comparison of:					
	A&B	A&C	A&D	B&C	B&D	C&D	A&B	A&C	A&D	B&C	B&D	C&D
SD	0.658	0.618	0.676	0.789	0.812	0.336	0.769	0.501	0.884	0.816	0.707	0.809
SE	0.208	0.196	0.214	0.249	0.257	0.106	0.243	0.158	0.279	0.258	0.224	0.256
"t" value*	2.210	1.535	0.935	0.641	1.013	0.939	1.809	0.063	2.002	1.667	0.536	2.148

A : Indoor rearing, first season (July–September, 1986).
B : Indoor rearing, second season (September–November, 1986).
C : Indoor rearing, third season (November, 1986–February 1987).
D : Outdoor rearing, second season (September–November, 1986).
* : Student's "t" test: "t" value at 9 df — 2.262 (at 95% C. L.).

TABLE 3. Effect of indoor rearing on cocoon characters of *A. paphia*.

Number of observations	Cocoon weight (g)				Shell weight (g)				Pupal weight (g)			
	A	B	C	D	A	B	C	D	A	B	C	D
1	5.9	4.4	7.7	4.8	1.5	0.5	1.0	0.6	4.2	3.8	6.7	4.1
2	3.7	8.0	2.9	5.5	1.3	0.8	1.0	0.4	2.4	7.3	1.9	5.1
3	6.5	5.4	6.1	8.0	0.7	0.6	0.8	0.7	5.8	4.7	5.3	7.2
4	3.7	7.5	3.0	5.6	0.5	0.6	0.5	0.8	3.1	6.8	2.4	4.6
5	4.2	7.2	5.3	4.3	1.7	0.6	0.6	0.5	2.5	6.5	4.6	3.8
6	4.1	8.1	5.0	8.5	1.5	0.9	0.8	0.7	2.5	7.1	4.0	7.8
7	3.2	4.5	4.3	5.2	1.2	0.5	0.6	0.5	2.1	3.9	3.7	4.6
8	3.3	5.1	3.1	3.9	1.0	0.6	1.3	0.4	2.3	4.5	1.8	3.5
9	3.1	5.6	3.7	4.6	1.3	0.6	0.5	0.3	1.8	5.0	3.1	4.0
10	5.0	6.1	4.5	5.1	1.6	0.5	0.5	0.4	3.3	5.5	3.9	5.2
Mean	4.27	6.19	4.56	5.55	1.23	0.62	0.76	0.53	3.0	5.51	3.74	4.99

	For comparison of:						For comparison of:						For comparison of:					
	A&B	A&C	A&D	B&C	B&D	C&D	A&B	A&C	A&D	B&C	B&D	C&D	A&B	A&C	A&D	B&C	B&D	C&D
SD	2.856	0.962	2.004	2.996	1.802	2.142	0.732	0.677	0.819	0.306	0.213	0.402	3.313	1.442	2.517	3.049	1.710	2.175
SE	0.903	0.304	0.634	0.946	0.570	0.677	0.231	0.214	0.259	0.097	0.067	0.127	1.048	0.456	0.796	0.964	0.541	0.719
"t" value	2.126	0.954	2.019	1.723	1.123	1.462	2.636*	2.196	2.317*	1.443	1.343	1.811	2.395*	1.623	2.500*	1.836	0.961	1.739

A, B, C & D: As in Table 2.
* "t" value: Means of parameters significant (Student's "t" test, at 95% C. L.)

was mostly nonsynchronous in indoor maintenance. However, the broad outline of each indoor generation tallied with that of the outdoor ones. Further, among the three outdoor maintained ones, the second generation (September - November, 1986) gave the best commercial cocoon characters. Therefore, it was taken for comparison with the indoor ones. CHAUDHURY (1981) reports that the autumnal (October-November) generation in the muga silkworm, *A. assama*, yields better, and therefore, is very popular among the commercial crops in Assam. Thus, our observations agree with those of CHAUDHURY (1981). Furthermore, during the indoor rearing in *A. paphia*, corresponding generation (September–November, 1986) demonstrated the maximum cocoon length (4.80 cm), cocoon weight (6.19 g) and the pupal weight (5.51 g) (Tables 2 and 3). However, only the pupal weight was statistically significant when compared with that of the first generation ("t" value: 2.305). On the contrary, this generation indicated less shell weight (0.62 g) as compared with that of the latter (1.23 g), which character was statistically significant ("t" value : 2.636) again.

Overall statistical analysis of the data from Tables 2 and 3, in respect of the cocoon length, cocoon circumference and the cocoon weight, revealed that none of these parameters demonstrated a statistically significant variation when compared among the three indoor generations, or the indoor generations with the outdoor one. It implies then that the indoor rearing is neither beneficial nor injurious in respect of these parameters. However, it is relevant to remember here, that during the indoor rearing, nearly 40% loss of yield is saved. Besides, the silk content in the form of shell weight appears to increase significantly ("t": 2.317) during the first generation (1.23 g) as compared to that of the outdoor generation (0.53 g) (Table 3). Therefore, from the point of view of commercial value of the cocoons, the indoor rearing appears to be quite beneficial.

Comparison of indoor rearing techniques:

Rearing of I, II and III instar larvae: JOLLY *et al.* (1974) have designed, and recommended the use of a rearing set for rearing *A. mylitta* larvae, up to the beginning of the I moult, only. The same set was also recommended for rearing *A. proylei* up to the third instar, and it is still in practice on commercial scale in the Western Himalayan region. Besides, KURIBAYASHI (1981) has succeeded in rearing *A. yamamai*, in boxes. However, we feel that the technique adopted by us for rearing early age larvae, i.e., the rearing in the sterilized bottles appears to be comparatively more convenient and suitable to our climatic conditions.

Rearing of IV and V instar larvae: JOLLY *et al.* (1974) have reared IV and V instar *A. proylei* larvae on matured twigs of Oak, hung on to the strings. This method is still in practice in Western Himalayan regions for commercial rearing. However, KURIBAYASHI (1981) has reported to have reared *A. yamamai*, on oak cut-shoots, kept dipped in water in the bottles, as well as in trays to rear by the box rearing method. We feel that the latter method is more suitable for the indoor rearing of *A. paphia* as the food plant the silkworm is relatively more delicate, and the climatic conditions in our region demand more protection against drying. Moreover, relevant rearing equipments are already available in this region.

Indoor spinning of cocoons: During the present study two types of cocoonages were tried: (1) made out of dried and left-out leaves and twigs of *Terminalia* (Fig. 5), (2) babmboo Chandrikes (Figure 6). The matured larvae which were hand picked at right time and released on Chandrikes yielded the clean cocoons (Fig. 8). Whereas, the other ones left in the trays with dry leaves pro-

produced fully scarred cocoons (Fig. 7). Thus the use of Chandrikes for indoor spinning was found to be more suitable. JOLLY *et al.* (1974) have reported that indoor spinning on hanging branches was as good as outdoor spinning. Moreover, such a method is being practised for the indoor spinning of *A. proylei*. However, we recommended the use of Chandrikes for this purpose in order to ensure clean cocoons.

On the whole, it appeared that the present study can provide some basic information about the possibilities for domestication of *A. paphia*. Further, improvisation and standardization of the indoor rearing techniques of the silkworm may enhance the scope and competence of the commercial production of the tasar silk. Therefore, the present study may open new avenues for keen considerations.

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DEVELOPMENT OF LIFE TABLES FOR *METASYRPHUS CONFRATER* (WIEDEMANN) (DIPTERA, SYRPHIDAE), A PREDATOR OF THE CABBAGE APHID (HOMOPTERA, APHIDIDAE) IN CAULIFLOWER CROP ECOSYSTEM

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Life tables were developed for *Metasyrphus confrater* (Wiedemann) (Diptera, Syrphidae), a naturally occurring predator of the cabbage aphid, *Brevicoryne brassicae* (Linnaeus) infesting cauliflower at Solan (1200 m msl, 30.55° North latitude and 70.09° East longitude), Himachal Pradesh, India. There was 76.09 and 90.08 per cent mortality in the winter (December-February), and spring generation (February-April), respectively. The egg and pupa were identified as critical stages, and infertility and parasitism as critical lethal factors. Positive trend index (1.527) and higher generation survival (SG) of 0.319 in the winter generation as compared to that of 0.933 and 1.104 in spring generation, respectively, revealed that whereas the syrphid showed better survival and increasing trend in population during winter, spring generation suffered a declining trend. Mortality factors, therefore, exerted greater influence on predator population during spring resulting in poor performance of the predator as biocontrol agent of the cabbage aphid.

(*Key words:* age-specific life tables, *Metasyrphus confrater*, *Brevicoryne brassicae*, predator, key mortality factor)

INTRODUCTION

Among naturally occurring biotic agents, syrphid predators are reported to bring about effective suppression of the cabbage aphid, *Brevicoryne brassicae* (Linnaeus) infesting cauliflower (*Brassica oleracea* var. *botrytis* L.) at Solan, Himachal Pradesh (KOTWAL, 1981; KOTWAL *et al.*, 1984) especially at low predator prey ratios. Of the nine species of aphidophagous syrphids reported from the state, *Metasyrphus confrater* (Widemann) has been found to be one of the most abundant species inhabiting cauliflower crop ecosystem (VERMA & MAKHMOOR, 1987). Various aspects of the biology of this species were studied by MAKHMOOR & VERMA (1987). The species is characterised by a voracious feeding in its larval stage, has high reproductive potential and synchronises well with prey population build-up under temperate climate occurring in the north western Himalayan regions (SIDDIQUI & KRISHNASWAMY, 1972; MAKHMOOR, 1985). However, the species is not devoid of its own natural enemies hitherto not reported earlier. Large number of parasites are repored to cause mortality to syrphids from different parts of the world (KAMAL, 1927; SCHNEIDER, 1969; PATEL & PATEL, 1969; ROTHERAY, 1981). However, the extent of mortality caused by various abiotic and biotic factors to *M. confrater* has not been studied. This information is of great practical significance as it will help in understanding the role this

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pecies could play in the suppression of *B. brassicae* and many other important aphid pests of economic crops.

In the present contribution, the age-specific distribution of mortality, its causes and their proportionate effects are expressed in the form of life tables as advocated by VARLEY (1970) and VARLEY & GRADWELL (1970, 1971). These tables were developed over a period of two years for two consecutive generations each year which the syrphid passed in cauliflower crop ecosystem, and pooled for each generation. The data were also used to identify stages and factors that are likely to cause variability in population density, either between or within generations, through key-factor analysis (MORRIS, 1959). The determination of key-factors responsible for mortality in a given population of biocontrol agent is not merely of theoretical interest but will eventually provide basis for its success in the field. This information will help in making prognosis of the effects of changes in the next or subsequent generations from information already in hand.

MATERIALS AND METHODS

Syrphid adults used in the study were collected from cauliflower fields during December and again in February in both the years. They were brought to the laboratory and held in nylon net cages (50 × 50 × 50 cm). Each cage was provided with a cotton swab soaked in 10 per cent honey solution and a few flowering shoots of mustard/cauliflower as food.

Field studies:

Life tables for the winter and spring generation of *M. confrater* were compiled for two years, 1982–1983 and 1983–1984, to determine timing, intensity and factors of mortality within generation. Since many species of syrphids share the same habitat, lay eggs on the same plant and the generations tend to overlap, it is cumbersome to take up such studies unless the populations are isolated. To simplify the studies, therefore, populations were artificially made into discrete generations by caging the laboratory held adults in nylon net cages and allowing them to oviposit on cauliflower plants carrying natural infestation of *B. brassicae*. These studies were conducted in a 0.25 ha plot pesticide free cauliflower crop ('cv. Snowball-16') grown for production of seeds. Four healthy plants were enclosed in each cage and flood irrigated. Before enclosing the plants all previously laid eggs as well as larvae of predators were carefully removed. Three pairs of newly mated adults were introduced in each cage and allowed to lay eggs for a period of 24 h. The cages were removed and leaves with eggs were marked by putting up number tags. Development and mortality in the cohorts was examined from the egg through pupal stage. In all, six cages were used in each generation and the data were averaged.

The age-specific life tables were developed by making use of column headings proposed by MORRIS & MILLER (1954), modified by MORRIS (1963). The overall plan for the life table was that of HARCOURT (1969) with slight modifications.

x = the age interval at which the samples were taken;

lx = the number surviving at the beginning of the stage noted in x column;

dx = the number dying within the age interval sated in x column;

dxf = the mortality factor, observed or presumed, responsible for dx.

For eggs, dxf included infertility, rainfall, wind and certain unknown causes. Shrivel-

led and dried up eggs were considered infertile whereas, emptied chorions indicated hatched eggs. A portion of the eggs found missing from the marked leaves was presumed dead since, even if hatched, the young larvae will fail to find their prey and would perish.

Owing to small size of the first instar larva, its lx value was determined by deducting dx value for eggs from the lx value, whereas, other instars were sampled directly on plants. Leaf litter provided at the base of the caged plants was examined for pupae which were then retrieved and brought to the laboratory for obtaining adult stage. Mortality caused through cannibalism among larvae was determined by observing emptied carcasses on marked leaves. Birds caused considerable mortality to larvae, the extent of which was determined by looking for characteristic rupturing of the leaf lamina harbouring the larva.

RESULTS AND DISCUSSION

A perusal of Table 1 reveals that in the winter generation bulk of the mortality

TABLE 1. The pooled life table of *M. confrater* for the winter generation (December–February) in cauliflower seed crop ecosystem.

x	lx	dxf	dx	100 qx	100 rx	log (lx)	'k'
Egg (estimated)	285					2.4548	
		k_1 Infertility	32				
		k_2 Abiotic & Unknown	27	20.70	20.70		0.1007
Larva							
1st instar (N_1)	226					2.3541	
		k_3 Bacteria	7				0.0360
		k_4 Unknown	11	7.96	6.32		
2nd instar	208					2.3181	
		k_5 Bacteria	31				
		k_6 Birds	15				
		k_7 Unknown	5	24.92	17.89		0.1222
3rd instar	157					2.1959	
		k_8 Bacteria	17				
		k_9 Birds	14				
		k_{10} Parasite (*Syrphophagus* sp.)	2	21.02	11.58		0.1025
Pupa	124					2.0934	
		k_{11} Bacteria	19				
		k_{12} Parasite (*Diplazon laetatorius*)	15				
		k_{13} Parasite (*D. multicolor*)	6				
		k_{14} *Syrphophagus* sp.	14	43.55	18.95		0.2483
Adult	70					1.8451	
		k_{15} Sex (52% females)	34				0.2769
Reproducing females (N_3 = 72)	36					1.5682	
Total					75.44		0.8866

Real mortality = 75.44 percent; Average facundity per female = 635;
Expected eggs = N3/2×Av. fecundity = 21,976; Dead/infertile eggs = 4549; Viable eggs = 17,427;
Expected number of young larvae in the next generation = 17,427; Actual number of young larvae in the next generation (N2) = 345; Trend index (I) = N2/N1 = 1.527; Generation survival (SG) = N3/N1 = 0.319.

(35.79 percent) occurred in the larval stage. Bacterial pathogen (*Bacillus* sp.) caused the maximum mortality among larvae in all the three instars. Birds were the other serious predators of larvae out of which *Acridotheres tristis* (Linn.) was the most common. These predators picked the grown up larvae leaving a scratch on the leaf lamina. First instar larvae generally escaped attack presumably due to their small size. SCHNEIDER (1947) reported robins (*Erithacus rubeculus* L.) and tits (*Parus major* L.) as predators of syrphid larvae and adults. The syrphid also suffered mortality due to some species of hymenopterous larval – pupal parasites namely, *Syrphophagus* sp. (Encyrtidae), *Diplazon laetatorius* (F.), *D. multicolot* Grav. and an unidentified species of *Diplazon* (Ichneumonidae). Hymenopterous parasites, particularly ichneumonids of subfamily Diplazontinae, are well documented natural mortality agents of syrphids causing as high as 80 percent mortality to larvae (KELLY, 1914; SCOTT, 1939; WNUK, 1974; PEK, 1979). Besides, some of the mortality could not be ascribed to any known biotic or abiotic cause.

There was 10.98 percent mortality in the pupal stage, either due to bacterial pathogen or by parasites which emerged as adults from parasitized pupae either singly (*Diplazon*) or in large numbers (av. 45.33 adults per pupa) as in case of *Syrphophagus* sp. The egg stage suffered 20.70 percent mortality on account of infertility and certain unknown causes. BANKS (1962) reported from UK that the ant, *Lasius niger* (L.) picked up eggs of syrphid flies. However, no such predator was observed in this study. The total generation mortality during winter season thus averaged 75.44 percent. The proportion of either sex in surviving aduls favoured females (52 percent). The species had the maximum generation time of 68 days during which a female laid an average number of 536 eggs. Based on these data, the generation survival (SG) was worked out as 0.319 and a rising trend in the population, the value of trend index (I) being 1.527.

Table 2 contains pooled life table data for the spring generation of *M. confrater*. The syrphid suffered mortality to the extent of 91.95 percent in this generation. The egg stage accounted for 20.69 percent mortality mainly due to infertility and certain unidentified causes. The highest proportion (44.59 percent) of mortality was observed in the larval stage and the mortality agents were either bacteria, bird predators or parasites namely, *Diplazon* sp., *D. laetatorius* and *Syrphophagus* sp. In this generation, mortality was higher than that observed in the winter generation. The species had shorter generation time of 44 days during which a female laid an average number of 245 eggs. The sex ratio was however, the same as observed in the winter generation. The generation survival was low (0.104) and the trend index was negative (0.933), which showed that mortality factors reduced the survival to a greater extent resulting in low activity in the next generation.

The key-mortality factors in both the generations were the bacterial pathogen and the larval-pupal parasites. The value of K (0.8866) in the winter generation showed an increasing trend in syrphid population in the next generation. Whereas, during spring, K value of 1.3832 indicated that there was declining trend in syrphid activity due to high mortality at various stages of its development. Working under similar environmental conditions, KOTWAL (1981) reported that *B. brassicae* populations showed declining trend index values as the cropping season progressed being 4.014 during January, 3.603 during February and 0.886 during March-April. He attributed this to the enhanced activity of biotic agents, particularly syrphid and coccinellid preda-

TABLE 2. The pooled life table of *M. confrater* for the spring generation (February-April) in cauliflower seed crop ecosystem.

x	lx	dxf	dx	100 qx	100 rx	log (lx)	'k'
Egg (estimated)	435					2.6385	
		k_1 Infertility	57				0.1007
		k_2 Abiotic & unknown	33	20.69			
Larva							
1st instar (N_1)	345					2.5378	
		k_3 Bacteria	29				
		k_4 Unknown	27	16.23	12.87		0.0769
2nd instar	289					2.4609	
		k_5 Bacteria	48				
		k_6 Birds	9				
		k_7 Parasite (*Syrphophagus* sp.)	12				
		k_8 Unknown	16	29.41	19.54		0.1513
3rd instar	204					2.3096	
		k_9 Bacteria	33				
		k_{10} *Syrphophagus* sp.	10				
		k_{11} Birds	10	25.98	12.18		0.1307
Pupa	151					2.1789	
		k_{12} Bacteria	22				
		k_{13} Parasite (*Diplazon laetatorius*)	31				
		k_{14} Parasite (*Diplazon* sp.)	30				
		k_{15} *Syrphophagus* sp.	33	76.82	26.67		0.6348
Adult	35					1.5441	
		k_{16} Sex (52% females)	17				0.2888
Reproducing females (N_3 = 36)	18					1.2553	
Total:					91.95		1.3832

Real mortality = 91.95 percent: Average facundity per female=245; Expected eggs N3/2 × Av. fecundity = 4410; Dead/infertile eggs = 912; Viable eggs = 3498; Expected number of young larvae in the next generation=3498; Actual number of young larvae in the next generation (N2)=322; Trend index (I) = N2/N1 0.933 General survival (SG) = N3/N1 0.104.

tors, which caused considerable suppression of the aphid in spite of its high fecundity and shorter generation time.

These studies thus pointed out that although *M. confrater* had high reproductive capacity, its value as potential natural control of *B. brassicae* could not be exploited fully since mortality agents exerted their influence on it and more so during spring season. The maximum potential of this species was operative in the early stages of aphid infestation (December-March) but later it became prone to its own natural enemies or migrated to other crops.

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Entomon 1989 Vol. 14 No. 3 & 4 pp. 233 to 236

TWO NEW SPECIES OF ERIOPHYID MITES (ACARI) FROM EASTERN INDIA

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(*Received* 2 *October* 1987)

Two new species of mites viz., *Baileyna indica* infesting *Ehretia acuminata* R. Br. and *Tegolophus birbhumensis* infesting *Litsea* sp. are described from eastern India. Relationship of these two species with the other known species of the genus and host mite relationship have also been provided.

(*Key words*: Acari, eriophyids, taxonomy, new species, West Bengal, Bihar, India)

Baileyna indica sp. nov. (Figs. 1–8)

Female: Body 127–187[2] long, 40–48 wide, white, worm-like. Rostrum 18-20 long, diagonal to the body axis; subapical seta obscure. Shield subtriangular without any anterior projection, 20-21 long and 28–30 wide; shield design simple, median faint, present in between 0.3-0.7 part, another diagonal line present near the base of dorsal tubercles and projected anteriorly up to a short distance; posterolateral angles of the shield granulated; dorsal tubercles on or very near to rear shield margin, 15–17 apart, dorsal setae 24–26 long, directing to rear. Foreleg 26–28 long from trochanter base; femur 7–9 long, seta 7–8 long; patella 3 long, seta 15–17 long; tibia 4–5 long, seta 3 long, tarsus 6–8 long with two upper setae each 15–16 long; claw simple, 6 long; feather claw 4-rayed. Hind-leg 21–23 long from trochanter base; patellar seta 9–11 long; two tarsal setae 15–17 and 7–11 long respectively; claw 9 long; other characters as in foreleg. Forecoxae centrally connate with a distinct sternal line, coxae smooth with all usual setae.

Abdomen with 42-50 faintly microtuberculated tergites and 50–59 round microtuberculated sternites; dorsal thanosome with three ridges that run parallel caudad, mid-dorsal ridge present only on middle part of abdomen. Lateral seta on sternite 8-10 and 15–17 long; first ventral seta on sternite 12–20 and 30–33 long; second ventral seta on sternite 30–33 and 6–8 long, third ventral seta on sternite 48-52 and 15-17 long; accessory seta very short; caudal seta 45-60 long. Genitalia 18-19 wide and 12-14 long; coverflap with 10-12 longitudinal scorings in single row; seta 4–6 long.

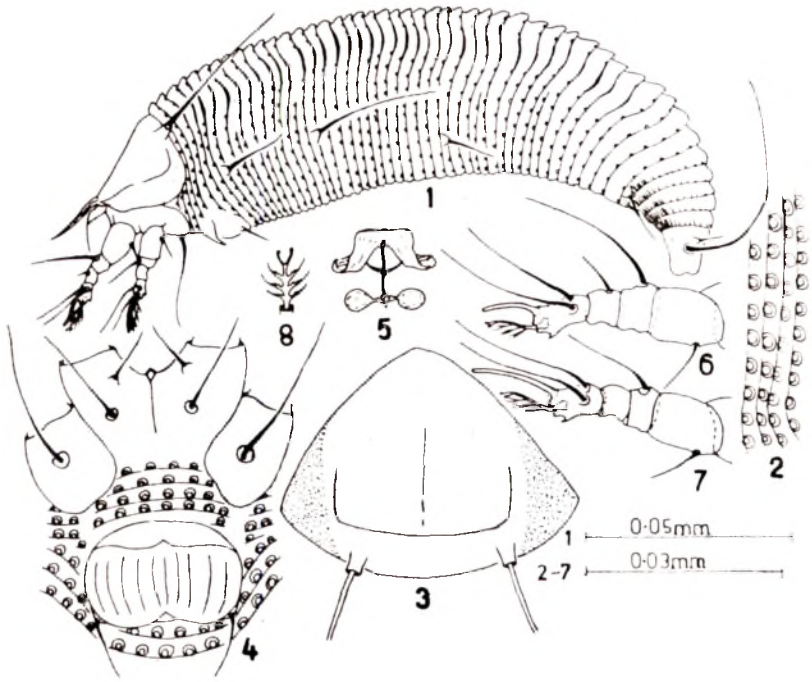
Male: Unknown.

Holotype: Female (marked), on slide (No. 303/134/82), INDIA : BIHAR : Santhalpargana, Massanjore, 15. v. 1982, infesting *Ehretia acuminata* R. Br. (Boraginaceae), coll. A. K. Das.

Paratypes: Many females on the holotypic slides and on 5 other slides (Nos. 384-388/134/82), collection data as in holotype.

Relation to host: The mites were found in pouch galls on the leaf.

[1]Deceased on July 18, 1987.
[2]All measurements are in micrometers (μm).



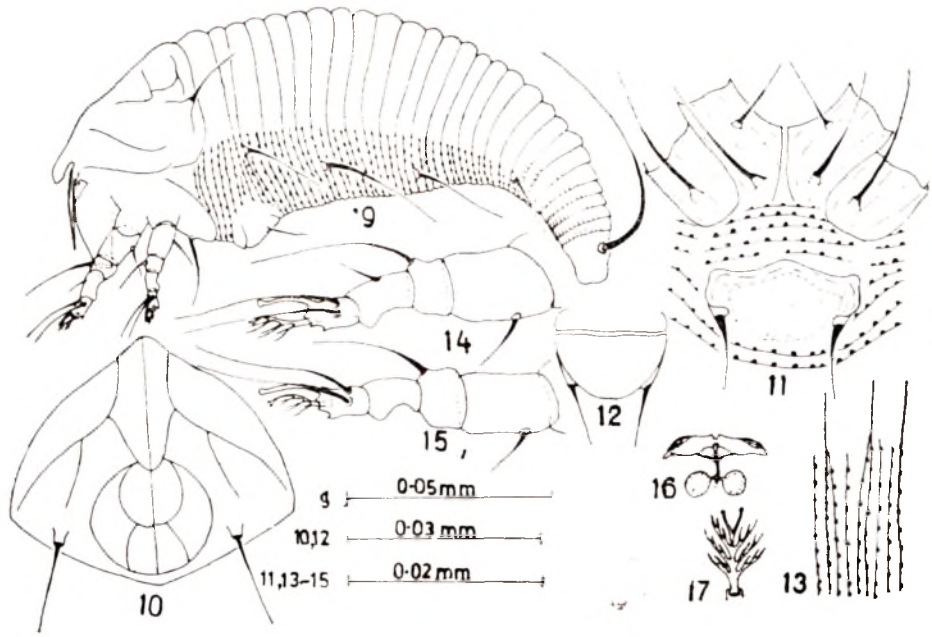
Figs. 1–8. *Baileyna indica* sp. nov.: Female. 1. Lateral view of mite; 2. lateral view of skin; 3. dorsal shield; 4. coxae with female genitalia; 5. apodeme; 6. Foreleg; 7. hind-leg; 8. feather claw.

Remarks: The genus *Baileyna* Keifer is so far monotypic and known by its type-species *B. marianae* Keifer (1954). The present new species differs from the former one in its distinct shield design with lateral granulation, round shaped sternal microtubercles and number of lines on genital coverflap.

Tegolophus birbhumensis sp. nov. (Figs. 9-17)

Female: Body 138-195 long, 54-63 wide; reddish in colour. Rostrum stout, 25-30 long; subapical seta 6-9 long. Shield subtriangular, apical lobe short; median line complete; admedian complete, curving out from anterior margin and giving off lateral line at 0.3 part of shield, then arching back to meet the median by cross lines at 0.5 and 0.75 parts of shield; the incomplete submedian curving back from middle shield, recurving centrad to meet in between dorsal tubercles; dorsal tubercles very near or on the rear shield margin, 28–37 apart; dorsal seta 12-16 long, directing to rear. Forelegs 28–30 long from trochanter base; femur 7–9 long, seta 7–9 long; patella 3 long, seta 17–12 long; tibia 7–8 long, seta 4–8 long; tarsus 6 long, tarsal setae two, each 15–20 long; claw slightly knobbed, 6 long; featherclaw simple, 4-rayed. Hind-legs 24-27 long from trochanter base; patellar seta 7-9 long, tarsus with two setae, 15–18 and 6–9 long respectively; other characters as in foreleg. Coxae ornamented with fine lines, inner margin of forecoxae separated, first setiferous tubercles placed at the level of fore–coxal approximation and further apart than second tubercles.

Abdomen with 25-28 moderately broad tergites and 60–70 fine microtuberculate sternites; dorsal thanosome with one mid-



Figs. 9–17. *Tegolophus birbhumensis* sp. nov.: Female. 9. Lateral view of mite; 10. dorsal shield; 11. coxae with external male genitalia; 12. female genitalia; 13. lateral view of skin; 14. foreleg; 15. hind-leg; 16. apodeme; 17. feather claw.

dorsal and two subdorsal ridges. Lateral seta 9–11 long, on sternite 9–12; first ventral seta 24–33 long, on sternite 20–24; second ventral seta 18 long, on sternite 34-41; third ventral seta 17-23 long, on sternite 54-65; accessory seta missing; caudal seta 45–53 long. Genitalia 21-22 wide and 15–16 long, coverflap smooth, seta 10–12 long.

Male: Body 139 long, 54 wide; shield 45 wide and 39 long. Genitalia 6 long and 15 wide; seta 9 long.

Holotype: Female (marked), on slide (No. 375/132/82), INDIA : WEST BENGAL: Birbhum, Ganpur, 15. v. 1982, *ex Litsea* sp. (Lauraceae), coll. A. K. Das.

Paratypes: Many females and few males on the holotypic slide and on 2 other slides (Nos. 376-377/132/81), collection data as in holotype.

Relation to host: The mites are simple leaf vagrants on ventral surface of leaves. No damage symptom is noticed.

Remarks: Among the species of the genus *Tegolophus* Keifer having 4-rayed feather claw, the present species is close to *T. ficusi* Mondal and Chakrabarti (1979), *T. spondiallus* Mondal and Chakrabarti (1981) and *T. vitexis* Mondal and Chakrabarti (1981) mainly by the presence of ornamented coxae smooth tergites, median shield line and absence of accessory seta. But it differs from all the above three species by its distinct shield design and smooth genital coverflap.

The type slides are deposited presently in the collections of Biosystematics Research Unit, Department of Zoology, University of Kalyani.

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IDENTIFICATION OF INDIAN SPECIES OF THE GENUS *ANOMIS* HÜBNER (OPHIDERINAE: NOCTUIDAE: LEPIDOPTERA)

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Male and female genitalic account of eight Indian species viz., *mesogona* Walker, *banzigeri* sp. nov., *flava* Fabricius, *sabulifera* Guenée, *metaxantha* Walker, *albitibia* Walker, *fulvida* Guenée and *lineosa* Walker referable to the genus *Anomis* Hübner have been illustrated. A key to these species has also been furnished by dwelling upon various morphological characteristics.

(*Key words:* *Anomis*, male, female., genitalia, *Cosmophila*, type species)

As such, besides placement, the species of the genus *Anomis* Hübner / *Cosmophila* Boisduval pose a serious problem regarding their identification. The superficial pattern of colouration viz-a-viz maculation of the species is more or less allied. Hampson (1894) under the genus *Cosmophila* reported ten species i.e., *mesogona* Walker, *sabulifera* Guenée, *trilineata* Moore, *fulvida* Guenée, *lineosa* Walker, *horsfieldii* Guenée, *sinuosa* Moore, *erosa* Hübner, *precedens* Walker and *fasciosa* Moore from British India and the genus was referred to the subfamily Gonopterinae. In a later publication, the author (Hampson, 1912) besides shifting the genus under the subfamily Noctuinae, also gave an account of the species *figlina* Butler, collected from Ceylon, India and Burma. However, Swinhoe (1919) reverted *Cosmophila* to the subfamily Gonopterinae while publishing brief notes on the structure of genitalia in six species i.e., *erosa* Hübner, *xanthindyma* Boisduval, *edentata* Walker, *lyona* Swinhoe, *dona* Swinhoe and *indica* Guenée the latter known to occur in India.

Tams (1924) transferred the species *fulvida* and *figlina* to the genus *Anomis* and the species *flava* and *sabulifera* were retained under *Cosmophila* Barnes and Benjamin (1926) have suggested that the generic name *Anomis* should presumably be used in the place of *Cosmophila*. Nye (1975) has explained that *Cosmophila xanthindyma* Boisduval, 1833 (a junior subjective synonym of *Noctua flava* Fabricius, 1775) and *Anomis exacta* Hübner 1822 are the type-species of the genera *Cosmophila* Boisduval, 1833 and *Anomis* Hübner, 1821 respectively. In the present communication, for obvious reasons, the authors have followed the generic name *Anomis* and this has also been recently used by workers such as Holloway (1977) and Banziger (1982).

During the course of present studies eight species viz., *mesogona*, *sabulifera*, *fulvida lineosa*, *flava*, *metaxantha*, *albitibia* and *banzigeri* sp. nov., collected during recently conducted surveys in various North and North-Eastern Indian localities have been, accordingly, treated under the genus *Anomis*. The male and female genitalia have been studied besides furnishing a key to Indian species of the genus *Anomis* Hübner as follows.

Genus *ANOMIS* Hübner

Hübner (1821) 1816, Verz. bekannter Schmettee: 249.

Type-species: *Anomis exacta* Hübner Syntypes ♂♀ (Mexico: Peru).

Anomis mesogona (Walker)

Walker, 1858, List. Spec. Lepid. Insects, 13:1002 (*Cosmophila*) Genitalia (male, Figs. 1, 2); uncus simple, sickle shaped, sclerotized, setosed, pointed at tip; gnathos notched apically; tuba analis prominent, tegumen elongated, lightly sclerotized; vinculum broad, 'V' shaped, saccus reduced; valva simple, elongated, sclerotized, sacculus region marked, costa reduced; transtilla simple, juxta well sclerotized, well developed; aedeagus long, slender with differentiation into base and apex; vesica simple, cornuti present. Female (Fig. 3): ovipositor lobes well sclerotized, setosed, posterior apophysis thinner than anterior apophysis; ostium bursae with margin sclerotized; ductus bursae long, thin walled, somewhat coiled, with posterior part sclerotized, while striated anteriorly; corpus bursae large, bag-like thin walled; signum present.

Wing expanse (half) : male : 21 mm.

Material examined : Himachal Pradesh: Sirmur, Kwagdhar, 2♂, 1♀, 21. v. 1984; 26. v. 1984.

Old distribution : throughout India; Ceylon; Burma; Java.

Anomis banzigeri sp. nov.

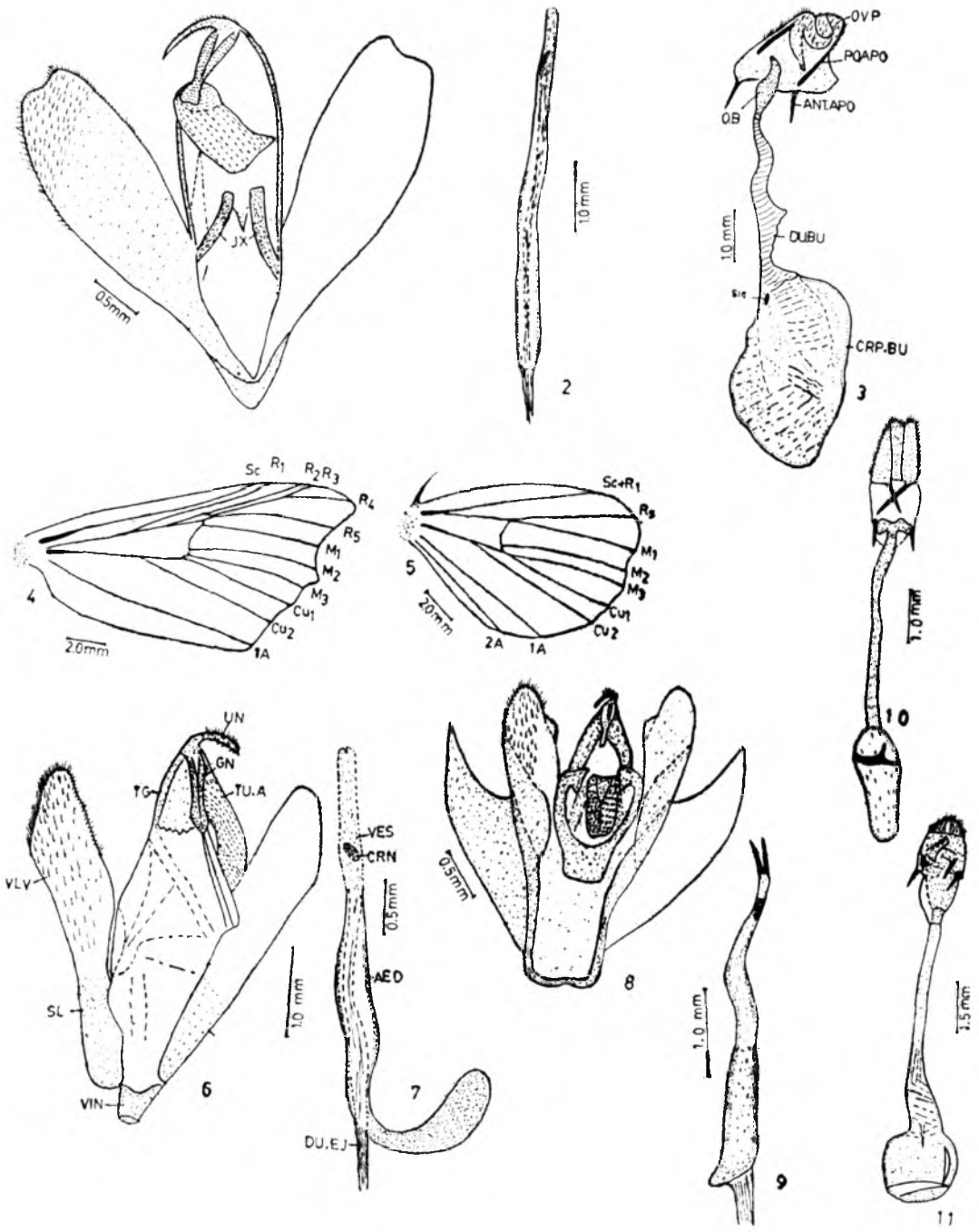
Adult : Head, thorax, tegula and patagium dark red brown; labial palpus upturned, second segment reaching level of vertex; antenna minutely ciliated; eyes red brown, with dark specks. Forewing with costal margin somewhat straight, apex produced or acute, outer margin angled at M_2, cilia dark, ground colour dark red brown, striated with grey, a short sub-basal line, an antemedial grey or brown line bent outwards at median nervure, then straight to inner margin, two black specks at the end of cell, oblique postmedial line meet the median line below discocellulars, an indistinct diffused submarginal shade, a marginal rufous line distinct. Hind-wing with tegmen uniform, ground color dark fuscous, underside with costa and outer area striated with red brown. Abdomen deep red brown, smoothly scaled, underside same as upper one, anal tuft dark red brown. Legs clothed with dark reddish scales, meso- and metalegs with outer tibial spurs nearly one-third the length of inner ones.

Venation (Figs. 4, 5): Forewing with discal cell more than half the length, R_1 from beyond the middle of cell, R_2 from much beyond the middle of areole, stalk of R_{3+4} longer than free branches of R_{3+4}, M_1 from anterior angle of cell, M_2 from well above posterior agle, Cu_1 from posterior angle, Cu_2 from well beyond the middle of cell. Hind-wing with discal cell more than one-third the length, Rs and M_1 connate basely, M_2, from above posterior angle, M_3 and Cu_1 with brief stalk at base, Cu_2 from three-fourths of cell. Genitalia (male, Figs. 6, 7): uncus simple, sickle shaped, slightly curved ventrad, setosed, pointed at tip; gnathos well developed, partially notched at free end; tuba analis well developed; tegumen elongated; vinculum narrow, V-shaped, well developed, saccus more or less conical; valva simple, costa and sacculus less marked; transtilla simple, juxta well sclerotized; aedeagus comparatively short, curved, one of the walls produced outwards vesica simple, cornuti present.

Wing expanse (half) : male : 19 mm; female: not studied.

Material examined : **Holotype** : ♂ Assam, North Cacher Hills, Jatianga, 17. ix. 1985.

As far as the general body colouration is concerned, the unnamed species goes nearer to *mesogona* Walker. The examination of



Figs. 1, 2. Male genitalia of *Anomis mesogona* (Walker); 3. Female genitalia of *A. mesogona* (Walker); 4, 5. Fore- and hind-wings of *A. banzigeri* sp. nov.; 6,7. Male genitalia of *A. banzigeri* sp. nov.; 8, 9. Male genitalia of *A. flava* (Fabricius); 10. Female genitalia of *A. flava* (Fabricius); 11. Female genitalia of *A. sabulifera* (Guenée). (For abbreviations used, see page 244).

the male genitalia of both the species show that though these are closely allied, they do depict differences in structures such as the uncus, juxta and aedeagus in the male genitalia. Besides, the maculation of the forewing of the new species is different from that of *mesogona*. The species is named as *banzigeri*, after the name of an eminent current Lepidopterist, Dr. H. Banziger, who has made commendable work on the systematics of some fruit- and blood-sucking moths of the family Ophiderinae.

Anomis flava (Fabricius)

Fabricius, 1775, Syst. Ent.: 601 (*Noctua*) Genitalia (male, Figs. 8, 9): uncus simple curved, very finely setosed, lightly sclerotized; gnathos well developed, notched at tip; tegumen long, narrow, sclerotized, broader, anteriorly; vinculum long, broad, well developed, saccus notched at middle anteriorly; valva symmetrical, costa arms not evident, sacculus rolled over inner margin forming a pocket like structure, rest of valva lightly sclerotized throughout; transtilla simple, juxta very pronounced, lateral arms rigid, knobbed, coremata very voluminous, single; aedeagus moderately long, narrow, curved at middle, cornuti scarcely evident.

Female (Fig. 10): Ovipositor lobes well sclerotized, finely setosed; posterior apophysis longer than anterior apophysis; ostium bursae simple, margins sclerotized; ductus bursae long, thin walled, tube like, without sclerotizations; corpus bursae balloon like; signum present.

Wing expanse (half): male : 16 mm female: 16 mm.

Material examined: Himachal Pradesh Sirmur, Nahan, 2 ♀♀; 18.ix.1984, Sirmur, Poanta Sahib, 1 ♀, 9. ix. 1984. Arunachal Pradesh: Tirap, Deomali, 3 ♂♂; 9. v. 1986. Punjab: Patiala, Punjabi University Campus, 8 ♂♂; 1♀, 28. viii. 1984-14. ix. 1984.

Old distribution : India; Ceylon; Burma; South China; Formosa; Japan; throughout Indo Malayan and Australian regions; Fiji.

Anomis sabulifera (Guenée)

Guenée, 1852, Hist, nat. Insects (Lepid.) 6: 404 (*Gonitis*) Genitalia (female, Fig. 11): ovipositor lobes well sclerotized, furnished with fine setae; posterior apophysis slightly longer than anterior apophysis; ostium bursae cup shaped, broad and sclerotized uniformly; ductus bursae long, thin walled, tube like corpus bursae differentiated into two parts, anterior globular, thin, posterior thick walled, with stripes.

Wing expanse (half): male : not studied. Female : 18 mm.

Material examined : Arunachal Pradesh : Tirap, Deomali, 1 ♀, 3. ix. 1986.

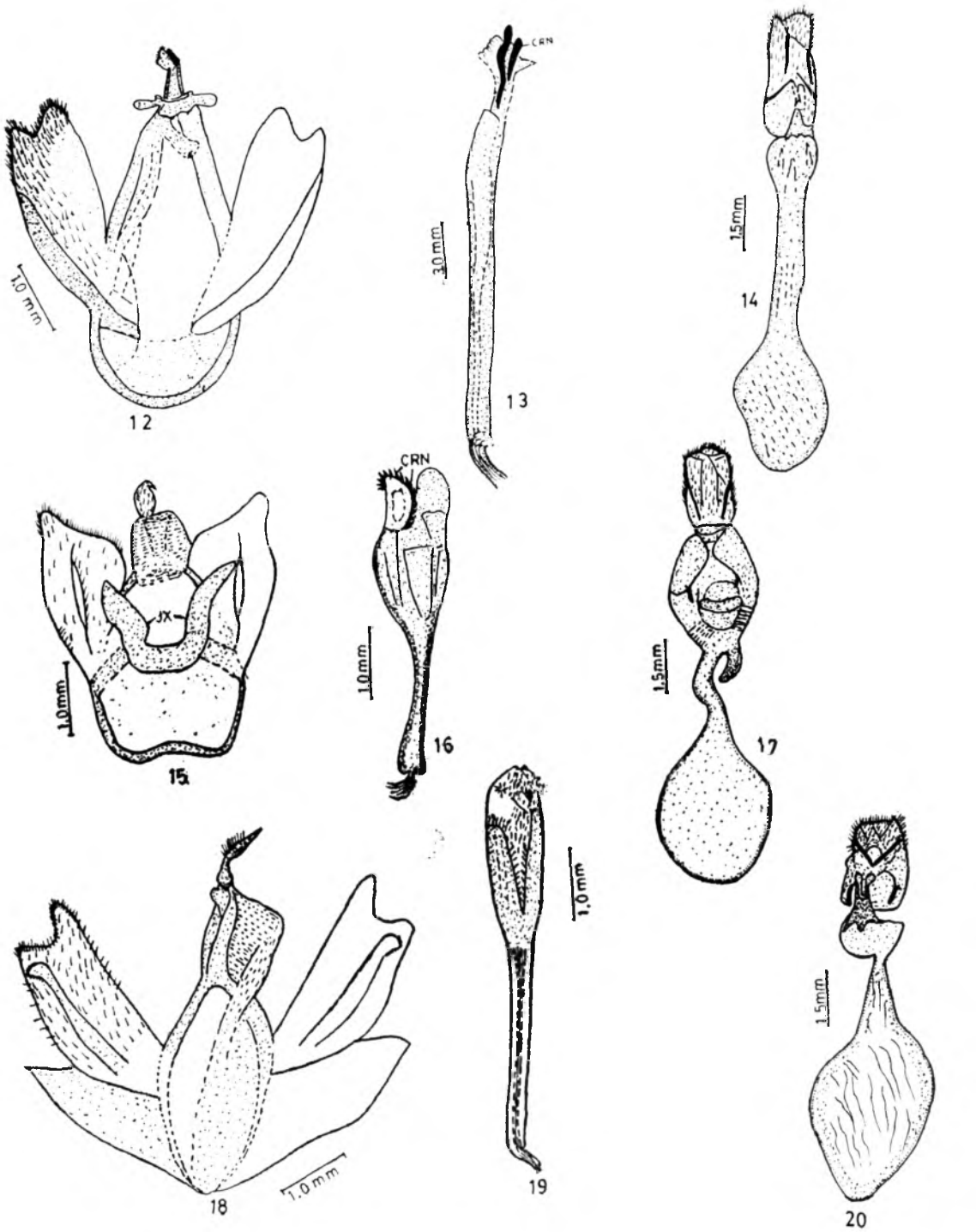
Old distribution : Throughout Africa: Aden; India; Burma; Ceylon.

Anomis metaxantha (Walker) n. comb.

Walker, 1858, List Spec. Lepid. Colln. Br. Mus 13:1005 (*Gonitis*) Genitalia (male, Figs. 12, 13): uncus highly sclerotized, setosed, taper distally; gnathos reduced; tegumen long, narrow uniformly sclerotized throughout the length; vinculum broadly rounded, saccus reduced; valva smoothly sclerotized throughout, finely setosed, costa marked, sacculus differentiated; transtilla membranous, juxta lightly sclerotized; aedeagus long, sclerotized uniformly, more on distal part; vesica with two well sclerotized cornuti.

Wing expanse (half) : male : 21 mm; female: not studied.

Material examined : Arunachal Pradesh: Tirap, Deomali, 1♂; 9. ix. 1985.



Figs. 12, 13. Male genitalia of *A. metaxantha* (Walker); 14. Female genitalia of *A. albitibia* (Walker); 15, 16. Male genitalia of *A. fulvida* Guenée; 17. Female genitalia of *A. fulvida* Guenée; 18, 19. Male genitalia of *A. lineosa* (Walker); 20. Female genitalia of *A. lineosa* (Walker). (For abbreviations used, see page 244).

Old distribution : Japan; China; throughout India; Ceylon; Burma; Java; Australia; Fiji; Samoa.

Anomis albitibia (Walker) n. comb.

Walker, 1858, List Spec. Lepid. Colln. Br. Mus. 13, 1001 (*Gonitis*) Genitalia (Fig.14) ovipositor lobes broad, well sclerotized, finely setosed; ostium bursae simple, sclerotized; ductus bursae long; uniformly sclerotized throughout the length; corpus bursae globular, thin walled, with fine striations.

Wing expanse (half) : male: not studied. Female : 22 mm.

Material examined : Arunachal Pradesh Tirap, Deomali, 1 ♀, 12. ix. 1986.

Old distribution : Samoa; Fiji; India; Burma; Java; Ceylon; China; Japan.

Anomis fulvida (Guenée)

Guenée, 1852, Hist. nat. Insects (Lepid.) 6: 397 (*Anomis*) Genitalia (Figs. 15, 16): uncus short, sclerotized, hood-like, pointed at tip, tuba analis prominent; tegumen broad; vinculum well developed, saccus broad, notched at middle; valva simple, uniformly sclerotized throughout, costal arm not evident, sacculus marked; transtilla membranous, juxta well pronounced, lateral arms solid, rigid, directed outwards; aedeagus characteristic type, divisible into narrow rod like proximal and broader vessel like distal part, vesica with cornuti arranged as bunch of flower.

Female (Fig. 17): ovipositor lobes broad, well sclerotized, setosed; ostium bursae well defined, bowl shaped; ductus bursae short, sclerotized; ductus seminalis originates from basal side of ductus bursae; corpus bursae thin walled, globular, balloon like, signum absent.

Wing expanse (half): male 23 mm; female 21 mm.

Material examined : Assam: North Cachar Hills, Jatinga, 1 ♂, 1 ♀, 17. ix. 1985-21 ix. 1985.

Arunachal Pradesh: Tirap, Deomali, 2 ♂♂, 4 ♀♀, 3. ix. 1986–8. ix. 1986.

Old distribution : Japan; China; throughout India; Ceylon; Burma; Java; Solomons; Fiji.

Anomis lineosa (Walker)

Walker, 1865, List. Spec. Lepid; Colln. Br. Mus. 33: 862 (*Cosmophila*) Genitalia (male, Figs. 18, 19): Uncus short, highly sclerotized, beset with fine setae at swollen part; gnathos rectangular in shape; tuba analis long; tegumen elongated, narrow, lightly sclerotized; vinculum narrow, more or less V-shaped, saccus reduced; valva simple, uniformly sclerotized, costa reduced saccular region membranous, harpe distinguished, distal portion of valva somewhat lobed, the latter beset with fine setae along its margin; transtilla membranous, juxta reduced; aedeagus moderately long, proximal part tube like, the distal part rosette like, highly sclerotized, bifurcated into two processess, beset with fine large number of spine like structures. Female (Fig. 20): ovipositor lobes well sclerotized, narrow, beset with fine setae; posterior apophysis slightly longer, thinner than anterior apophysis; ostium bursae somewhat elongated, highly sclerotized; ductus bursae very short uniformly sclerotized; corpus bursae differentiated into three portions, anterior large, globular with apex conical, wall irrorated with stripes, middle portion somewhat funnel like, tapering posteriorly, posterior part shorter, thin walled, globular, with its connection with ductus bursae distinctly sclerotized; ductus seminalis departs from posterior portion of corpus bursae.

Wing expanse (half) : male: 23 mm, female : 25 mm.

Material examined : Assam: North Cacher Hills, Jatinga, 2♂♂, 2♀♀, 17. ix. 1985-25. ix. 1985.

Old distribution : Sikkim, Nagas, Nilgiris.

Whereas all the above species can be segregated on different morphological characters such as maculation, venation and armature of legs, they do have some common characteristics as is evident from the present study. For instance, the labial palpi are always upturned with second segment reaching vertex of head and third being long, slender and furnished with a blunt frontal tuft. The antennae are minutely ciliated or pectinated in males. The scales on the thorax and abdomen are smoothly arranged. The apex of the forewings are produced and acute with the outer margin angled or bulged out to a point in the middle. The discal cell is either half or more than half the length of the forewing. Except *sabulifera* and *albitibia*, the gnathos is notched apically in the male genitalia of the remaining six species. Further, the valvae are simple (constituent parts not distinct) and uniformly sclerotized throughout. In the female genitalia, the ostium bursae are sclerotized.

KEY TO THE SPECIES OF THE GENUS *ANOMIS* HÜBNER

1. Hind-wing with veins M_3 and Cu_1 shortly stalked beyond posterior angle..... 2

— Hind-wing with veins M_3 and Cu_1 connate at posterior angle..... 3

2. Wings greyish brown, forewing with posterior line angled below costa, then uncurved and meet medial line on discocellulars; male genitalia with gnathos deeply notched distally aedeagus moderately long, slender, walls smooth..... *mesogona* (Walker)

— Wings reddish brown, forewing with postmedial line oblique and meet the medial line below discoellulars; male genitalia with gnathos slightly notched distally, aedeagus comparatively shorter, curved, with one of its walls produced outwards.....*banzigeri* sp. nov.

3. Hind-wing with veins Rs and M_1 briefly stalked beyond anterior angle of cell..... 4

— Hind-wing with veins Rs and M_1 not stalked with veins Rs and M_1 stalked beyond anterior angle of cell..... 5

4. Forewing with basal half carrying a large yellow patch, the latter irrorated with red; female genitalia with signum present in corpus bursae..... .....*flava* (Fabricius)

— Forewing with ground color uniformly light reddish; female genitalia without a signum in corpus bursae.....*sabulifera* (Guenée)

5. Forewing more or less vinous red or dark brown vein R_5 from areole..... 6

— Forewing not as above, vein R_5 from the same point of origin of R_3+_4..... 7

6. Forewing vinous red, with a yellow spot below costa and one at end of cell..... .....*metaxantha* (Walker)

— Forewing dark red brown, without any spot as above.....*albitibia* (Walker)

7. Hind-wing light fuscous, forewing with bright ferruginous or yellowish red-brown; male, genitalia with juxta extremely modified, uncus hood-like, with long pointed tip; female genitalia with ductus bursae not broadened at ostial end..... .....*fulvida* Guenée

— Hind-wing dark fuscous brown, forewing dark brown; male genitalia with juxta not as above (simple) uncus simple, uniformly broad throughout except apex, the latter somewhat pointed; female genitalia with ductus bursae broadened at the ostial end.....*lineosa* (Walker)

ACKNOWLEDGEMENT

The financial assistance provided by CSIR, New Delhi during the tenure of the project on Noctuid moths is gratefully acknowledged.

ABBREVIATIONS USED

1A, first anal vein; 2A, second anal vein; AED, aedeagus; ANT. APO, anterior apophyses; CRN, cornuti; CRP.BU, corpus bursae; Cu_1, first cubital vein; Cu_2, second cubital vein; DU.BU, ductus bursae; DU.EJ ductus ejaculatorius; GN, gnathos; JX, juxta; M_1, first median vein; M_2, second median vein; M_3, third median vein; O.B., ostium bursae; OVP, ovipositor; PO. APO, posterior apophyses; R_1, first radial vein; R_2, second radial vein; R_3, third radial vein; R_4, fourth radial vein; R_5, fifth radial vein; Rs, radial sector; SA, saccus; $Sc+R_1$, stalk of Sc and R_1; SL sacculus; TG, tegumen; TU. A., tuba analis; Un, uncus; VES, vesica; VIN, vinculum; VL V, valva.

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TWO NEW SPECIES OF *ISOTIMA* FOERSTER (HYMENOPTERA: ICHNEUMONIDAE) FROM INDIA[1]

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Two new species of the genus *Isotima* Foerster *viz.*, *I. aurangabadensis* and *I. dorsalis* from Maharashtra, India are described and illustrated. A note on male genitalia of *I. aurangabadensis* is provided.

(*Key words:* new species of *Isotima*, Hymenoptera, taxonomy, genitalia)

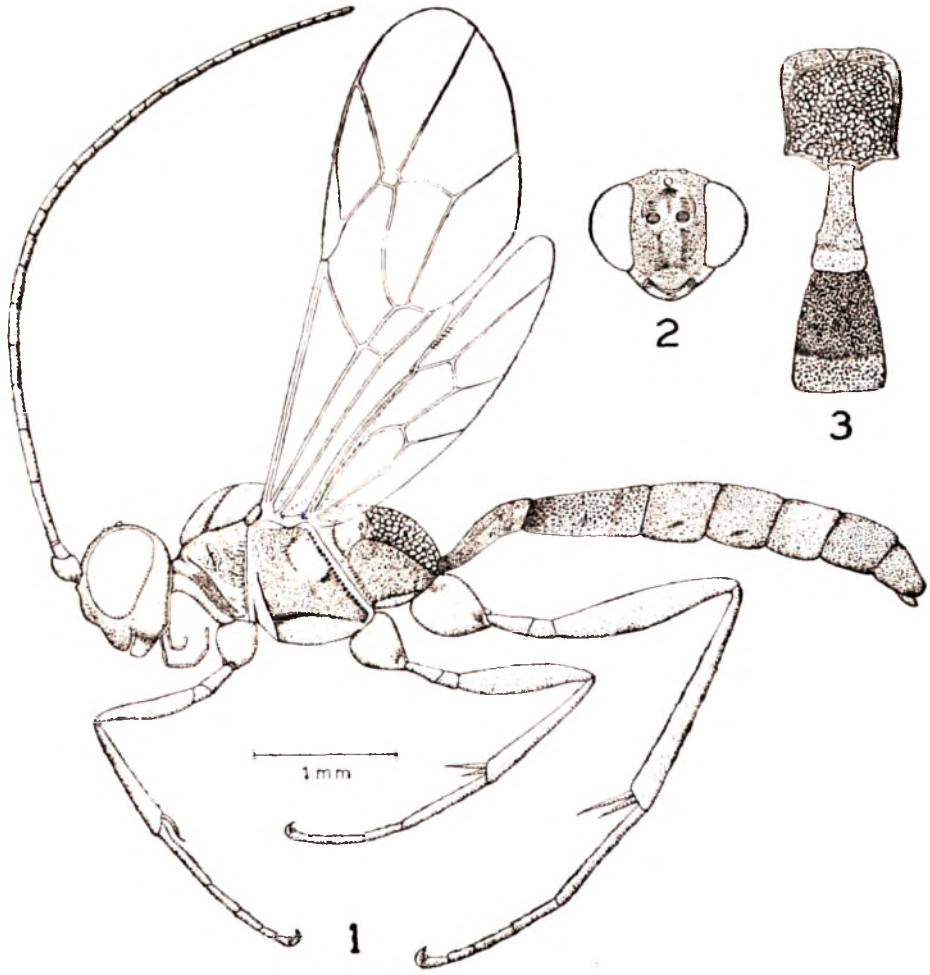
Foerster (1868) described *Isotima* without designating type species. Ashmead (1905) described four species from the Philippines under *Isotima*, of which *I. albicineta* was selected by Townes (1957) as the type species for this genus and simultaneously synonymised *Formostemus* Uchida and *Fotsiforia* Seyring with *Isotima*. Townes *et al.* (1961) synonymised *Gambroides* Betrem and *Vadonina* Seyring with this genus, included fourteen species and one unnamed species from Indo-Australian region. Jonathan (1980) studied in detail *Isotima* complex and revalidated *Gambroides* (=*Vadonina*), *Formostenus* and *Fotsiforia*, which were considered as synonyms of *Isotima* by Townes (1957) and Townes *et al.* (1961). He included nineteen species under *Isotima* which occur only in Oriental region, divided these species into three groups *viz.*, (A) the Bicarinata, (B) the Tricolar and (C) the Albicineta and provided a well defined key to the species. Later, Jonathan (1982) added one more species namely *I. andamanensis* from the Andaman Islands (India). In the present study, the key to the species of *Isotima* by Jonathan (1980) has been followed and two new species *viz.*, *I. aurangabadensis* and *I. dorsalis* are described from Maharashtra. Further, a note on the genitalia of the male of *I. aurangabadensis* is also added.

The type material of these species are in Entomology Research Laboratory, Department of Zoology, Marathwada University, Aurangabad and will be deposited in national collection of Zoological Survey of India, Calcutta in due course.

1. Isotima aurangabadensis, sp. nov. (Figs. 1–3; 4–5).

Male (Fig. 1): Body 6.15 mm long. Head (Fig.2) 0.80 as long as broad; vertex rugoso-punctate; ocelli separated from eyes by 1.50× their diameter; frons weakly, obliquely, striato-punctate below median ocellus, rest rugoso-punctate; antennal sockets bordered by weak semicircular carinae, medially striate; antennae 2+27 segmented; scape 1.50× as long as broad; pedicel 2× as long as broad; first flagellar segment 1.50× as long as the length of scape and pedicel combined, 1.20× the length of second segment; terminal segment 2.50× as long as broad; face 0.65 as long as broad, laterally grooved at laterad of antennal sockets to clypeo-facial suture, medially weakly convex, finely rugoso-punctate; clypeus 0.50 as long

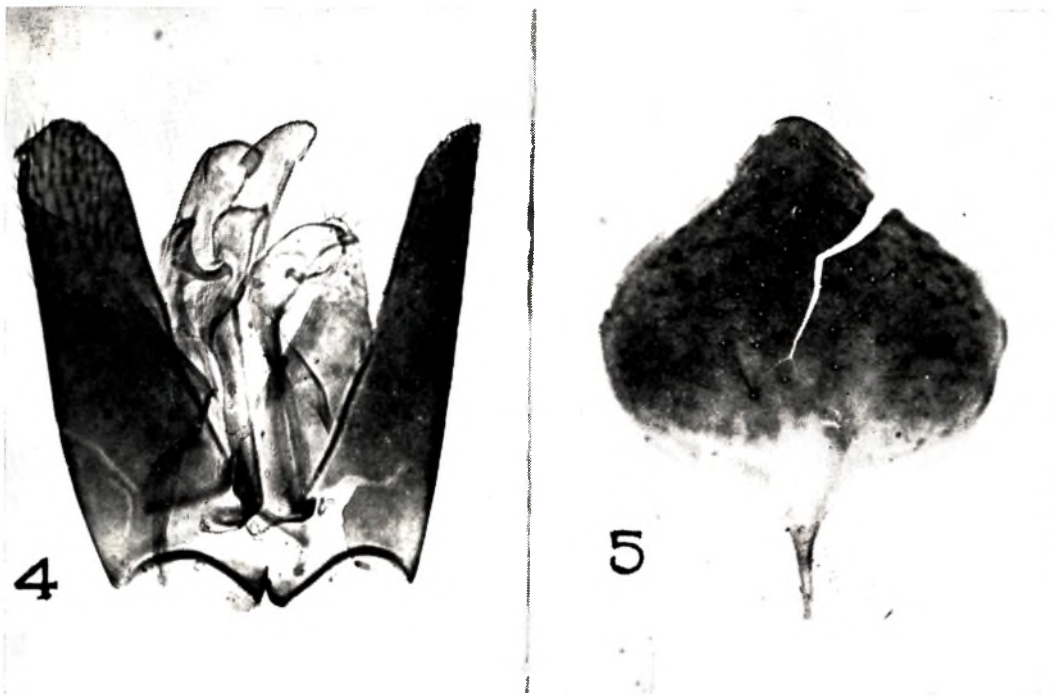
[1]Part of Ph. D. thesis submitted to Marathwada University, Aurangabad.



Figs. 1–3. *Isotima aurangabadensis*, sp. nov. 1. Adult male lateral view; 2. Head viewed from front; 3. Propodeum with 1st and 2nd terga.

as broad, convex, basally rugoso-punctate, apically densely punctate, extreme apical margin shiny; mandible moderately short, weakly striato-punctate towards base, teeth equal; maxillary palpi long, reaching up to the centre of mesosternum; cheek 0.65 the basal width of mandible, granulose; temple apically broader, widely rugoso-punctate, dorsally finely rugoso-punctate; occiput smooth and shiny; occipital carina complete above; genal carina straight, joining to oral carina just behind the base of mandible.

Thorax (Fig. 1) 1.60× as long as broad; collar shiny above, rest weakly longitudinally striate, intermixed with sparse punctures; pronotum obliquely rugoso-striate in the middle, upper margin closely, minutely punctate, lower margin minutely punctate, epomia strong, reaching the upper margin; mesoscutum convex, minutely, closely punctate, notauli deep, reaching behind the middle; scutellum closely punctate, lateral carinae extending up to 0.60; postscutellum smooth, shiny; propodeum (Fig. 3) between basal carina and apex finely rugoso-reticul-



Figs. 4–5. *Isotima aurangabadensis*, sp. nov. 4. Male genitalia; 5. Subgenital plate.

ate, basad to basal transverse carina rugoso-punctate, basal transverse carina present, medially weakly bowed, apical transverse carina absent, apophysis in the form of indistinct crest, pleural carina present, spiracles circluar; propleurum finely, closely punctate; mesopleurum closely punctate; punctures coalescent, speculum minutely, weakly punctate, anterior margin of speculum with short striae, prepectal carina extending 0.60 the height of mesopleurum, sternaulus exending up to the base of middle coxa; metapleurum rugoso-punctate, juxtacoxal carina complete; hind-femur 4.70× as long as its median width, basitarsus 0.85 the length of rest of tarsus, claw 2.30× as long as broad, simple weakly curved apically. Fore wing 3.90 mm long, 1.25 mm braod; basal abscissa of radius 0.70 the length of its apical abscissa; areolet sessile, pentagonal, as high as the portion of second recurrent above the bulla, 1.10× as long as broad, second intercubitus faint; second recurrent inclivous, weakly curved, medially fenestrate, 0.45 the length of basal abscissa of subdiscoideus, latter 1.45× the length of its apical abscissa; nervulus slightly distad to basal vein, inclivous, 0.50 the length of postnervulus; latter intercepted at 0.35; second discoidal cell 2.75× as long as broad discocubital cell 3.30× as long as broad; hind-wing 2.75 mm long 0.60 mm broad, with 1+7 hamuli; basal abscissa of radiella 0.25 the length of its apical abscissa; basal abscissa of cubitella 1.25 × as long as its apical abscissa; basal half of mediella straight, apically strongly arched; superior and inferior nervellar abscissae in the ratio 2:3; brachiella absent.

Abdomen 1.40× the length of head and thorax combined; first tergum (Fig. 3) mat, laterally rugulose, 2.10× as long as broad, 0.90 the length of second tergum, without

dorsomedian carinae, spiracles at 0.65; rest of terga closely, finely punctate.

Colour: Black; antennae brownish-black to brownish except scape and pedicel dorsally, thorax except pronotal collar, first tergum basally and dorsomedially reddish-brown; fore and mid-legs except coxae and trochanters; hind-femora basally brownish; hind-legs blackish-brown except coxae apically, trochanters and femora basally; scape and pedicel dorsally, mandible except teeth, palpi, pronotal collar, forecoxae, trochanters, hind-coxae apically, trochanters basally, first tergum apically and laterally, second to third terga and seventh tergum apically and following terga yellowish-white.

Genitalia (Fig. 4) moderately sclerotized, situated on sclerotic ring, consists of aedeagus, gonoforceps and volsellae; aedeagus elongate, spatha flattened, blunt, parameres slightly flattened, ergot slightly oblique, rod-like; gonoforceps short, moderately truncate, gonosquamae blunt, gonostipes flattened, gonocardo blunt; volsellae enclosed in gonoforceps, gonolaciniae tapered, distivolsellae moderately tapered, apically blunt, ventral area of basivolsellae flattened, basivolsellar strut oblique; subgenital plate (Fig. 5) moderately cubical, flat, sparsely punctate, proximally with long spiculum, anticosta curved.

Female: Unknown

Holotype: ♂, INDIA: MAHARASHTRA: Aurangabad, Bhaosinghpura, 22. xi. 1982 on wing, Coll. L. J. Kanhekar, wings mounted on slide and labelled as above.

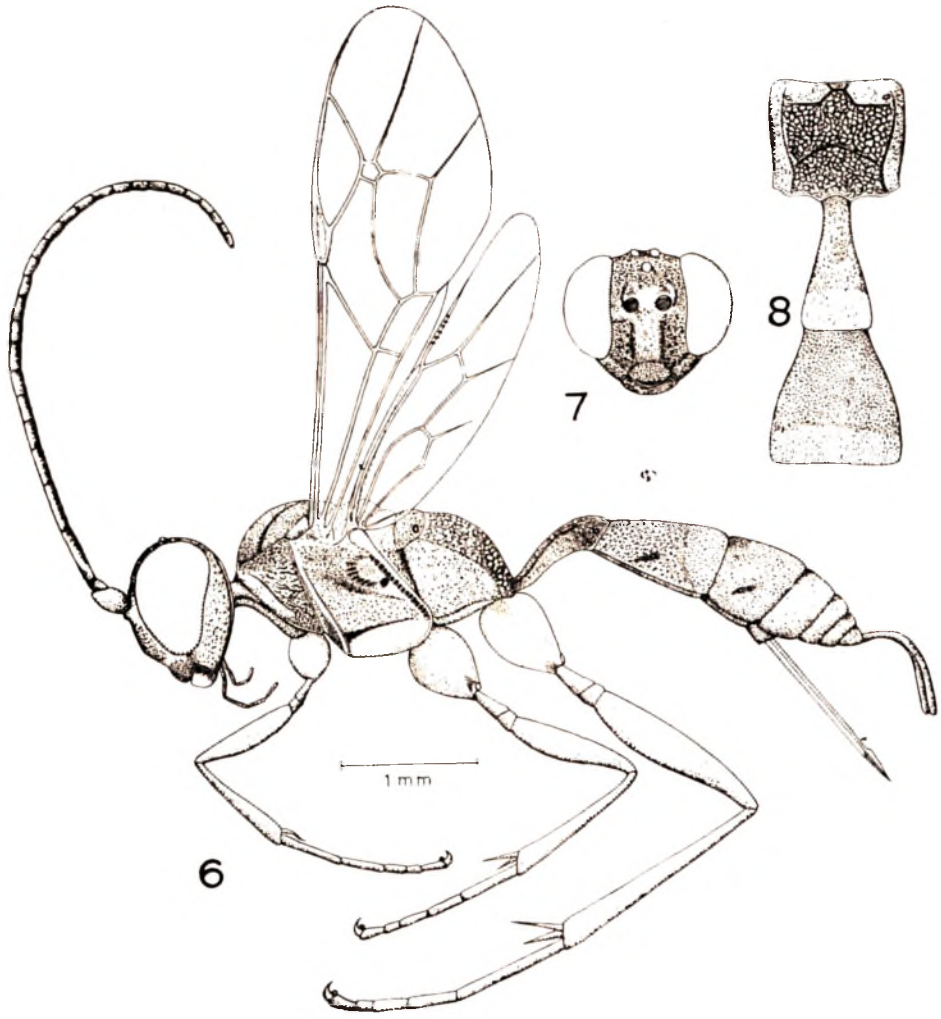
Paratype: ♂, data same as holotype except locality and date, Cantonment, 9. ix. 1982.

Remarks: According to the key to the species of *Isotima* by Jonathan (1980) this species fits in the Tricolor group and resembles *I. punctata* Jonathan but it differs from the same in having: face and vertex rugoso-punctate; frons below median ocellus weakly, obliquely striato-punctate; pronotum obliquely rugoso-striate in the middle; lateral carinae of scutellum extending upto 0.60; post-scutellum smooth and shiny; prepectal carina extending up to 0.60; metapleurum rugoso-punctate; propodeum between basal transverse carina and apex finely rugoso-reticulate, apical transverse carina absent; first tergum without dorsomedian carina; nervellus intercepted at 0.40 above the middle; thorax reddish-brown except pronotal collar yellowish-white; hind-coxae apically brownish; cuspis with 5 hairs and subgenital plate distally strongly truncate.

2. Isotima dorsalis, sp. nov. (Figs. 6-8)

Female (Fig. 6): Body 5.85 mm long, head (Fig. 7) 0.85 as long as broad; vertex closely punctate; ocelli separated from eyes by 1.30× their diameter; frons rugoso-punctate; antennal sockets transversely striate, laterally smooth and shiny; antennae 2 + 25 segmented; scape 1.20× as long as broad; pedicel 2× as long as broad; first flagellar segment 1.10× the length of scape and pedicel-combined, 1.15× the length of second segment; terminal segment 2× as long as broad; face 0.60 as long as broad, vertically laterally grooved, medially weakly convex, rugoso-punctate; clypeus 0.60 as long as broad, closely, densely punctate, apical margin impressed; mandible stout, basally striate with weak punctures, teeth slightly subequal, maxillary palpi long, reaching up to the centre of mesosternum; cheek as long as the basal width of mandible, granulose; temple apically broader, broadly rugoso-punctate; occipital carina complete above; occiput smooth and shiny; genal carina sinulate, joining the oral carina far above the base of mandible.

Thorax (Fig. 6) 2.50× as long as broad; collar subshiny; pronotum obliquely rugoso-striate in the middle, upper margin finely rugoso-punctate, lower margin densely punc-



Figs. 6–8. *Isotima dorsalis*, sp. nov. 6. Adult female lateral view; 7. Head viewed from front; 8. Propodeum with 1st & 2nd terga.

tate, epomia strong, reaching up to upper margin; mesoscutum convex, minutely closely punctate, notauli strongly impressed, reaching behind the middle; scutellum closely punctate, lateral carinae extending up to0.75; postscutellum indistnictly punctate; propodeum (Fig. 8) between basal transverse carina and apex finely rugoso-reticulate, basad to basal transverse carina laterally rugoso-punctate, both transverse carinae bow shaped, apophysis in the form of low crest, pleural carina distinct, spiracles circular; propleurum minutely, closely punctate; mesopleurum finely, minutely rugoso-punctate except medially closely punctate, obliquely grooved from the apex of prepectal carina, speculum weakly, densely punctate, anterior margin of speculum with short striae, prepectal carina extending 0.80 the height of mesopleurum, sternaulus extending up to the base of middle coxae; metapleurum finely rugoso-punctate juxtacoxal carina distint; hind-femur 4.85× as long as its median width, tibia 1.85× the length of ovipositor sheath, basitrasus 1.10×

the length of rest of tarsus, claw 2.50× as long as broad, simple. Forewing 3.90 mm long, 1.25 mm broad; basal abscissa of radius 0.85 the length of its apical abscissa; areolet sessile, pentagonal, as high as broad, 1.60× as high as the portion of second recurrent above bulla, second intercubitus faint, intercubitii weakly convergent; second recurrent weakly reclivous, medially fenestrate, 0.40 the length of basal abscissa of subdiscoideus; latter 1.45× the length of its apical abscissa; nervulus inclivous, very slightly distad to basal vein, 0.60 the length of postnervulus, latter intercepted at 0.35; second discoidal cell 2.85× as long as broad; discocubital cell 3.80× as long as broad; hind-wing 2.60 mm long, 0.55 mm broad, with 1+6 hamuli, basal abscissa of radiella 0.30 the length of its apical abscissa; basal abscissa of cubitella 1.50× the length of its apical abscissa; mediella strongly curved apically; superior and inferior nervellar abscissae in the ratio 1:2; brachiella absent.

Abdomen 1.10× the length of head and thorax combined; first tergum (Fig. 8) dorsally mat, laterally rugulose, with lateral teeth at base, dorsomedian carina distinct, apically 2× as long as broad, as long as second tergum, spiracles at 0.70, close to each other; second tergum densely, closely punctate; third tergum densely, minutely closely punctate; rest of the terga weakly closely, minutely punctate; ovipositor long, straight, tip tapering beyond raised nodus, lower valve apically with distinct series of oblique ridges; ovipositor sheath 0.55 the length of the hind-tibia.

Colour: Black; mandible except teeth, palpi, scape, pedicel and basal two flagellar segments, fore legs, mid-femora, tibiae, tarsus dark-brown; forefemora apically and tibiae laterally brownish; thorax red; mid-coxae, trochanters reddish; hind-legs more or less blackish except trochanters, femora basally and tibiae lighter; apices of first and second terga, seventh and eigth terga yellowish-white; ovipositor brown; ovipositor sheath blackish.

Male: Unknown.

Holotype: ♀. INDIA: MAHARASHTRA: Aurangabad, Bhaosinghpura, 13. xii. 1983, on wing, Coll. L. J. Kanhekhar, wings mounted on slide and lebelled as above.

Paratype: 1♀, INDIA: MAHARASHTRA: Nashik, 21. viii. 1984, on wing, Coll. S. K. Nikam.

Remarks: In accordance with the key to the species of *Isotima* by Jonathan (1980) this species fits in Tricolor group and runs close to *I. annulata* Jonathan in the characters as per key. However, it differs from the same in having: face and frons rugoso-punctate; pronotum obliquely rugoso-striate in the middle, upper margin finely rugoso-punctate, lower margin densely punctate; mesopleurum minutely rugoso-punctate except medially closely so, obliquely grooved from apex of prepectal carina; juxtacoxal carina complete; ovipositor sheath 0.55 the length of hind-tibia; thorax red and hind coxae black.

Isotima aurangabadensis, sp. nov. and *I. dorsalis*, sp. nov. may be included in the key to species of Isotima (Jonathan, 1980) as follows:

7. Pronotum trans-rugose in middle; metapleurum and propodeum closely punctate. India ..... *punctata* Jonathan, 1980.

— Pronotum coarsely trans-striate or obliquely rugoso-striate; metapleurum rugose or rugoso-punctate; propodeum rugoso-reticulate..... 7a

7a. Vertex rugose-punctate; postscutellum smooth and shiny; prepectal carina extending up to 0.60; apical transverse carina of propodeum absent; thorax reddish-brown except pronotal collar yellowish-white..... ..... *aurangabadensis*, sp. nov.

— Vertex punctate; postscutellum minutely punctate; prepectal carina extending up to 0.75 – 0.80; apical transverse carina of propodeum present; thorax red or black 7b

7b. Flagellum banded above; frons with distinct oblique striations below median ocellus, rest densely punctate; cheek 0.85 the basal width of mandible; pronotum coarsely trans-striate; lateral carinae of scutellum extending up to 0.45; metapleurum weakly rugose; first tergum without dorsomedian carina; areolet as high as the portion of second recurrent above bulla; thorax black. India ....*annulata* Jonathan, 1980.

— Flagellum without band; frons rugoso-punctate; cheek as long as basal width of mandible; pronotum obliquely rugoso-striate; lateral carinae of scutellum extending up to 0.75; metapleurum finely rugoso-punctate; first tergum with dorsomedian carina; areolet 1.60× as long as the portion of second recurrent above bulla; thorax red.....*dorsalis* sp. nov.

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The author is highly thankful to Dr. P. K. NIKAM, Reader, Department of Zoology, Marathwada University, Aurangabad for guidance and Prof. R. NAGABHUSHANAM, Head of the Department for providing laboratory facilities during the course of this study. I am also thankful to CSIR, New Delhi for the award of Junior & Senior Research Fellowship. The help rendered by Dr. S. K. PATNAIK, Assistant Director RFT & RC, NICD, Rajahmundry is gratefully acknowledged.

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DROSOPHILA LONGIVITTATA, A NEW SPECIES OF *HIRTODROSOPHILA* FROM SALEM (TAMILNADU: INDIA)

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This report describes a new species, *Drosophila* (*Hirtodrosophila*) *longivittata* from India and also gives its taxonomic relationship with other species of *Hirtodrosophila*.

(*Key words:* *Drosophila longivittata*, Salem, *Hirtodrosophila*)

The Indian subcontinent with its vast array of vegetation and climate harbours many species of *Drosophila*. During the last few decades several investigators have surveyed the *Drosophila* fauna in various parts of South India (Reddy and Krishnamurthy, 1968, 1977; Sajjan and Krishnamurthy, 1975; Gowda, 1979; Gai, 1985). However, these workers have concentrated their attention only on the Western Ghats, the Andaman and Nicobar Islands etc. (Prakash and Reddy, 1979; Ranganath *et al.*, 1983). Therefore, the survey of *Drosophila* was made in Salem, Tamil Nadu, located at the foot of the Servarayana Hill ranges which forms part of Eastern Ghats. The town is characterised by low rain fall and high temperature (max. 42°C). Collections were made by trapping the flies on banana baits and net sweeping over rotting fruits in the backyards of houses. A new species collected in the net during sweeping is described here under.

Drosophila longivittata, sp. nov.

Males and females: Light gray flies with five remarkably dark longitudinal stripes; one median dorsal, two are dorsolateral and two are lateral (Figs. 1a & 1b). Females are larger than males. The mean body length for female 1.35 and for male 1.28 mm.

Head: Arista with 4 dorsal branches in addition to the terminal fork. Antenna gray; basal segment of the antenna bears a pair of dark bristles. The median stripe originates on the lower segment of each antenna, the two meet together below the antenna and run posteriorly. Palp with a large and many small bristles. Vibrissae with two anterior and two posterior large bristles. In between the anterior and posterior bristles are 10–12 small bristles. Dorsal portion of the vibrissae is drakly pigmented. Carina narrow greyish, cheeks broad, anterior orbitals small reclinate median reclinate, anterior orbitals half the size of median, posterior equal to anterior. Anterior verticals large and directed inwards; posterior convergent and crossed. Ocellar triangle dark with a pair of large dark bristles. Eyes dark red. Longest axis of eye nearly rectangular.

Thorax: Greyish with 5 stripes. Acrosticals in 8 regular rows. Dorsocentrals convergent. Anterior dorsocentrals are shorter than the posterior approximately half the length of the posterior. Anterior scutellar convergent, posterior scutellar convergent and crossed. Both anterior and posterior scutellars are of equal length. Prescutellars are absent. Scutellum has three stripes. Median stripe ends blindly at the posterior tip of the scutellum. The two dorsolateral stripes originate on the dorsal side of head near the inner margin of eyes and run posteriorly up to the tip

of the abdomen. The lateral stripes originate on the lateral side of thorax and run posteriorly on the lateral side up to the tip of the abdomen. Two humerals. Upper humerals half the length of the lower. Posterior alars slightly longer than anterior. Notopleurals and supra-alars are of equal length. Anterior sternopleurals 3/4 the length of posterior. There are 20–25 smaller bristles along with anterior and posterior sternopleurals. Halteres translucent.

Wings: Smoky and hyaline. Wing length, male: 0.79 mm, female 0.85 mm. The wing indices are calculated following the formula of Okada (1956) and presented in Table 1.

Legs: No sex comb or cuneiform bristles. Preapicals on all the three tibiae, apicals on the middle.

Abdomen: males and females: Greyish with four stripes, all four stripes confluent at the posterior end of the abdomen. Tergites heavily pigmented near stripes. No sexual dimorphism in males and females.

Internal characters: Malpighian tubules colourless, posterior tubules are free at the tips. Testes long with 5–6 coils, colourless (Fig. 2). Ovary with large number of ovarioles, ventral receptacle long with 20–25 loose coils. Spermatheca pale yellowish brown, roundish (Fig. 3).

Periphallic organ: (Fig. 4): Epandrium broad, apically narrow, deeply concave. Heel constricted, toe rounded with about 3–4 bristles curved inwards. Surstylus with about 15 thick teeth unevenly distributed. On the inner margin of primary surstylus there are about 10 thick curved bristles. Cercus rounded on the outer side and slightly curved on inner side, and with about 25 long and short bristles.

Phallic organ (Fig. 5): Aedeagus and anterior gonapophysis are fused to form a stout structure (spindle). Posterior gonapophysis absent. Novasternum with three pairs of long median spines. Ventral fragma broad and concave. Basal apodeme is thick and short.

Egg guide (Fig. 6): Brown in colour, with about 15–18 marginal and 4–5 discal teeth. The teeth are also brownish.

Egg (Fig. 7): Egg with 4 filaments. Anterior two filaments are thin and pointed while the posterior two are club shaped.

Pupae (Fig. 8): Yellow with about 10 spiracular filaments. At the posterior end there are 5 pairs of projections, two pairs are lateral, two pairs are dorsal and one pair is ventral in position.

Holotype: Male: INDIA, TAMILNADU, Salem, 27.vi.1988. Coll. S. N. Hegde. V. Vasudev, M. K. Naseerulla and M. Jayashankar. Deposited in the *Drosophila* vivarium of Department of Zoology, University of Mysore, Manasagangotri, Mysore-570 006, India.

Allotype: Female: Same as above.

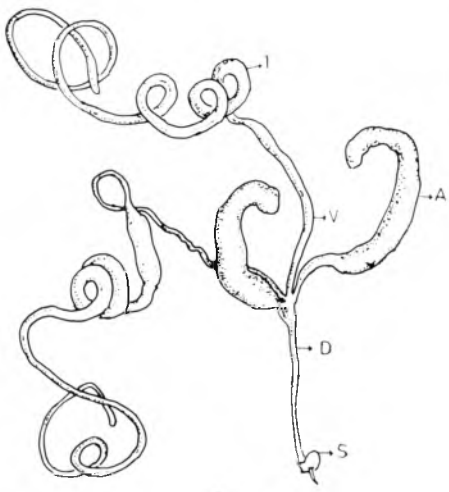
Paratype: 5♂♂ and 5♀♀, INDIA, TAMILNADU, Salem, Coll. S. N. Hegde, V. Vasudev, M. K. Naseerulla and M. Jayashankar.

TABLE 1. Wing indices of *D. longivittata* (Mean values for 10 flies).

Sex	Costal index	4V index	4C index	5X index
Male	1.90	2.11	1.29	1.61
Female	1.83	2.53	1.60	1.71

1a

1b



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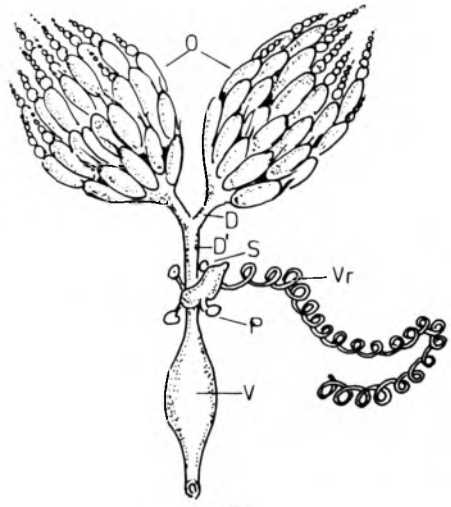

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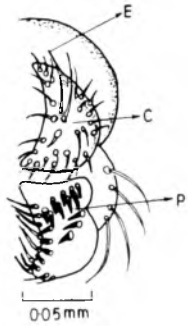

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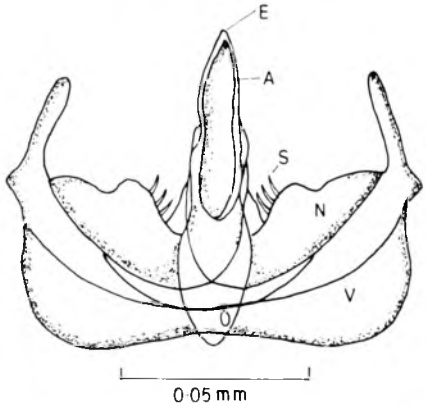

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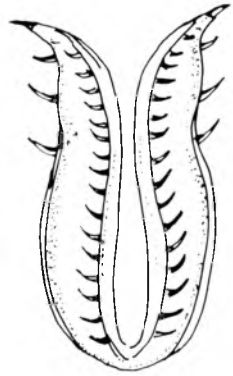

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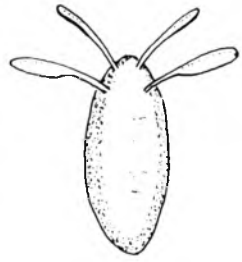

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Fig. 1(a) Dorsal view; (b) side view. Fig. 2. Male and female reproductive system respectively; T–Testis; V–Vasa deferentia; A–Paragonia; D–Anterior ejaculatory duct; S–Sperm pump. Fig. 3. Female reproductive system; O–Ovaries; D–Oviduct; D'–Common oviducts; S–Spermathecae; Vr–Ventral receptacle; P–Paraovaria; V—Vagina. Fig. 4. Periphallic Organ; E–Epandrium; C–Anal cercus; P–Primary surstylus; Fig. 5. Phallic Organ; E–Aedeagus; A–Anterior gonopophysis; S–Spines; N–Novasternum; O–Basal apodeme; V–Ventral fragma; Fig. 6. Egg guide. Fig. 7. Egg. Fig. 8. Pupa.

3♂♂ and 3♀♀ deposited with Prof. T. Okada, Department of Biology, Tokyo Metropolitan University, Setagayaku, Tokyo, Japan.

Remarks: The flies are colleted from the backyards of houses, by sweeping on rotting fruits. They may be cultured in the laboratory with wheat cream-agar medium or cornmeal agar medium. In the laboratory they are slow breeders.

Relationships: The species described above may be included under the subgenus *Hirtodrosophila* because it has the following features: the longest axis of the eye rectangular, the novasternum with submedian spines, egg guide with yellowish brown bristles. The presence of dark longitudinal stripes on the body; Malpighian tubules free at the tips and common stalk at the base, long coiled ventral receptacle are characteristic features that demand the inclusion of the species under *quadrivittata* species group. The species differs from *D. pentavittata* (Gupta and Raychaudhuri, 1970) and *D. pentastriata* (Okada, 1966), in characters such as the nature of stripes, number of branches in the arista, colour of spermatheca, non-annualar stalk of spermatheca in the present species and the structure of phallic organ.

According to Okada (personal communication) the new species is related to *D. trivittata* (Strobl, 1893) of *quadrivittata* species group. The common characters between *D. trivittata* and the new species are: humerals 2, upper one longer than lower, preapicals on all tibia and apicals on middle etc. The new species has certain distinct features such as presence of 5 longitudinal stripes, four egg filaments, absence of tuft of three stout bristles on the cerci, nature and number of teeth on the surstylus. Hence the species has been given an independent status and named as *Drosophila longivittata.*

ACKNOWLEDGEMENT

The authors are highly thankful to Prof. N. B. KRISHNAMURHTY, Chairman, Department of Zoology, University of Mysore, Mysore, for encouragement and providing facilities, Dr. M. E. GURURAJ, Reader and Dr. V. VASUDEV, Lecturer, Department of Zoology, University of Mysore, Mysore, for help during collection and critical discussions, Prof. T. OKADA, Department of Biology, Tokyo Metropolitan University, Setayaya-Ku, Tokyo, Japan for his help in identifying the new species and to Mr. N. R. PRASAD for drawings. MKN and MJ are grateful UGC and University of Mysore, for financial assistance through awarding the fellowships.

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BIOLOGICAL NOTES ON PINE - INFESTING APHID, *CINARA ATROTIBIALIS* (HOMOPTERA : APHIDIDAE)

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Cinara atrotibialis, **monophagous on *Pinus kesya*, feeds on 1-4 years old pine trees. Population trend shows an alternate rise and fall with a reverse trend for its endoparasitoid, *Pauesia laricis*. Young aphids usually dominate the population structure and incidence of alatae is very low. The species leads anholocyclic life cycle.**

(*Key words:* pine aphid, biology)

INTRODUCTION

Cinara atrotibialis David and Rajasingh, 1968 is one of the 12 species under the genus infesting *Pinus kesya* in the hills of Meghalaya and Manipur states in north east India. GHOSH (1982) provided the taxonomic account of this endemic species. This is apparently the first attempt to study the biology of any *Cinara* species from India.

MATERIALS AND METHDOS

Bimonthly observations in respect of feeding sites, aphid-infestation in relation to host-age, population trend and life cycle were taken in and around Shillong during the period from June 1987 to April 1988. Counting of aphids was done following random sampling method from 4 shoots of each of the 50 pine trees in the age group of 1-4 years. Beyond this age group plants showed negligible infestation. Most of the observations were made within an area of few square miles at an altitude of 1000 - 15000 meters.

RESULTS AND DISCUSSION

Feeding site:

The dark brown aphids are most usually encountered on the open-grown small trees having a height of little over one to four feet. The feeding sites did not vary much from one tree to another or one locality to another. However, slight differences were noticed according to the age group of the host. The usual feeding sites are: *On small tree* (1–2 *years old*): 1. small twigs at the end of main branches and in the crown; 2. apical shoots at the bases of needles; *On large trees* (3–4 *years old*): 1. in the branches near the tip or unopened buds; 2. at the junction of branches or main branch and its crown.

Not all the parts of a plant are equally suitable sources of food for aphids. They show a tendency to colonise parts of a plant on which they can achieve the highest growth and developmental rates (KENNEDY *et al.*, 1950). The little variation in the feeding sites of *C. atrotibialis* from small to large trees is a testimony of this fact

Niche preference:

The aphid occurred above *c* 1100 m although young and old trees of *P. kesya* are distributed from an altitude of *c* 600 m. Very young trees (6 months to 1 year old) and pines in nursery bed were not colonised by aphids. Trees older than 4 years were seldom found infested. Infestation was

TABLE 1. Aphid preponderance in relation to age of the host.*

Host age	Aphid preponderance (percentage)				
	Up to 10	11–25	26–50	51–75	75–100
1 week	—	—	—	—	—
1 month	—	—	—	—	—
6 months	—	—	—	—	—
1 year	2	—	—	—	—
2 years	—	—	46	—	—
3 years	—	—	—	68	—
4 years	—	—	32	—	—
5 years or older	1.5	—	—	—	—

* based on 400 observations during 10 months period.

very common in 2-3 years old trees and less so in 3–4 years old pines (Talbe 1).

The quality of the phloem sap and structure and chemistry of the plant surface and its internal tissues determine the distribution of aphids between and on the host plant (DIXON, 1985). Since the physical structure and quality of the phloem sap changes with the growth of the plant, it is likely that pine trees older than 4 years do not offer acceptable conditions for the feeding of aphids.

Population trend:

The species showed a population trend of alternate rise and fall during the period of study (Fig. 1). Maximum population was observed in June and minimum in the months of August and December. Young aphids (I-IV instars) usually exceeded the combined number of apterae and alatae in the population. Incidence of alatae was found to be very low (0.87 – 1.19%) and occurred for about 6 months only. Population of *Pauesia laricis* (Haliday), the hymenopteran endoparasitoid, was recorded throughout the year and its incidence showed almost a reverse trend of population to its host.

Aphids respond to its environmental changes (food quality, plant structure,

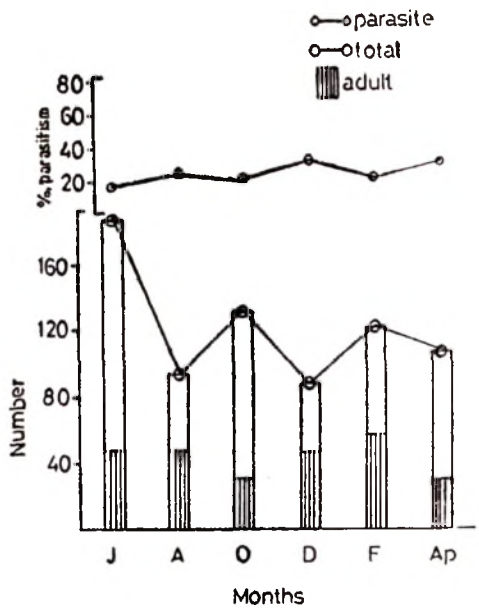

Fig. 1. Population trend of *Cinara atrotibialis* and its endoparasitoid *Pauesia laric's* on *Pinus kesya*.

natural enemies, temperature, day length, rainfall) by regulating its reproductive strategy and morphic state (DIXON & WELLINGS, 1982). No doubt, natural enemies also regulate the level of population to a certain extent (VAN DEN BOSCH, 1979). The results of the present study suggest that the endoparasite is responsible for every fall in population as these were the only natural enemies encountered. Intrestingly, the aphid population never collapsed beyond a limit (47.54% of the maximum) and this may be due to the fact that the endoparasite species parasitised mostly the fourth instar and newly moulted adult apterae leaving the young aphids largely undisturbed. As a result number of adult individuals in the population remained low throughout the year and natality of the population was checked due to continuous exposure of the adults to endoparasites. The success of such direct host-parasite interaction is rare (VAN DEN BOSCH, *op. cit.*) and may be attributed to homogeneity in their habit and habitats. A further investigation on quantifying the effect of parasitisation will give more appropriate clue in this regard.

Life cycle:

Based on field observations and analysis of population data from June 1987 to April 1988 (Fig. 1), it is noticed that *C. atrotibialis* is monophagous on *Pinus kesya* in the hills of Shillong and occur by its anholocyclic parthenogenetic morphs only.

ACKNOWLEDGEMENTS

Thanks are due to Department of Science and Technology, New Delhi for financing the work through a research project. Due thanks are also extended to the Head, Department of Life Science, for provoding necessary working facilities.

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FOUR NEW SPECIES OF ERIOPHYOIDEA (ACARI) FROM TAMIL NADU

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Received 20 *July* 1988

Four new species of eriophyid mites viz. *Paraphytoptus jujubae* **sp. nov.,** *Eriophyes ensifotiae* **sp. nov.,** *Neodicrothrix piperae* **sp. nov. and** *Acarhynchus bamboovegrans* **sp. nov. have been described and reported from Tamil Nadu.**

(*Key words:* new Eriophyoidae, Acari)

In the course of survey, collection and study of phytophagous mites in Tamil Nadu, four new eriophyid mites were encountered. They have been adequately sketched and described. The type and paratype slides containing holotypes and paratypes have been deposited in the Department of Agricultural Entomology collections, Tamil Nadu Agricultural University, Coimbatore-641 003, India. In the descriptions, all measurements given are in micrometers.

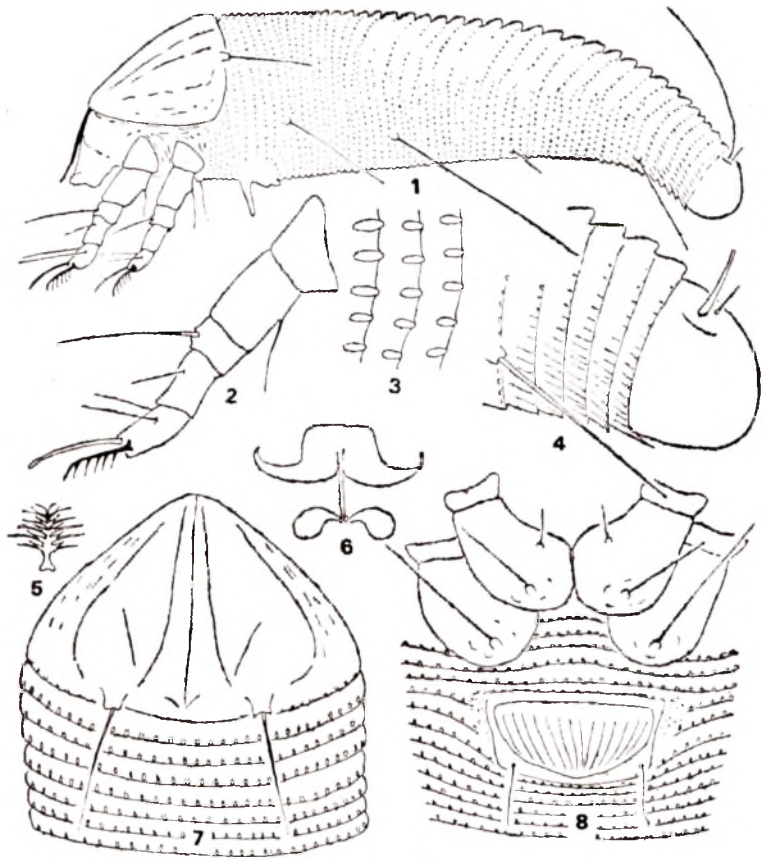
1. **Paraphytoptus jujubae,** sp. nov. (Fig. 1–8)

Female: 115–120 long, white, worm like; 35 thick, rostrum 15 long, evenly down curved, antapical seta 5 long. Shield 25 wide, 20 long; with a pattern of thin lines; median complete with an arrow like extension on the posterior end; admedians complete; first submedian short, diagonal and represented in the posterior half of the shield; second submedian curved forming the border of the shield; sides of shield with light scrorings; dorsal tubercles at rear shield margin, 11 apart; dorsal setae 20 long pointing backwards. Foreleg 20 long; tibia 5 long tibial seta 4 long: tarsus 6 long; claw 7 long curved and tapering; feather claw simple 6 rayed; hind-leg 18 long; tibia 4 long, tarsus 5 long; claw 7 long; all usual setation present. Coxae with a clear sternal line; all three setiferous tubercles present; coxal area nearly smooth. Abdomen with about 42 tergites which become broader in the posterior half; and with about 60 sternites; rings with microtubercles along the posterior margin; lateral seta 15 long on ring 10; first ventral seta 32 long on ring 22; second ventral seta 6 long on ring 36; third ventral seta 16 long on ring 6 from behind; caudal seta 65 long, accessory seta 2 long. Female genitalia 15 wide, 7 long; coverflap with 14 lines; genital seta 17 long.

Male: Unknown

Types: Holotype ♀ marked on slide and 5 slides containing paratypes; all with ♀♀, INDIA: TAMIL NADU: Coimbatore, 15. v. 1985 ex *Zizyphus jujuba* (Rhamnaceae) M. Mohanasundaram Coll: (No. 545) (TNAU).

Relation to host: The mites are under surface leaf vagrant found among hairs with no symptoms of damage.



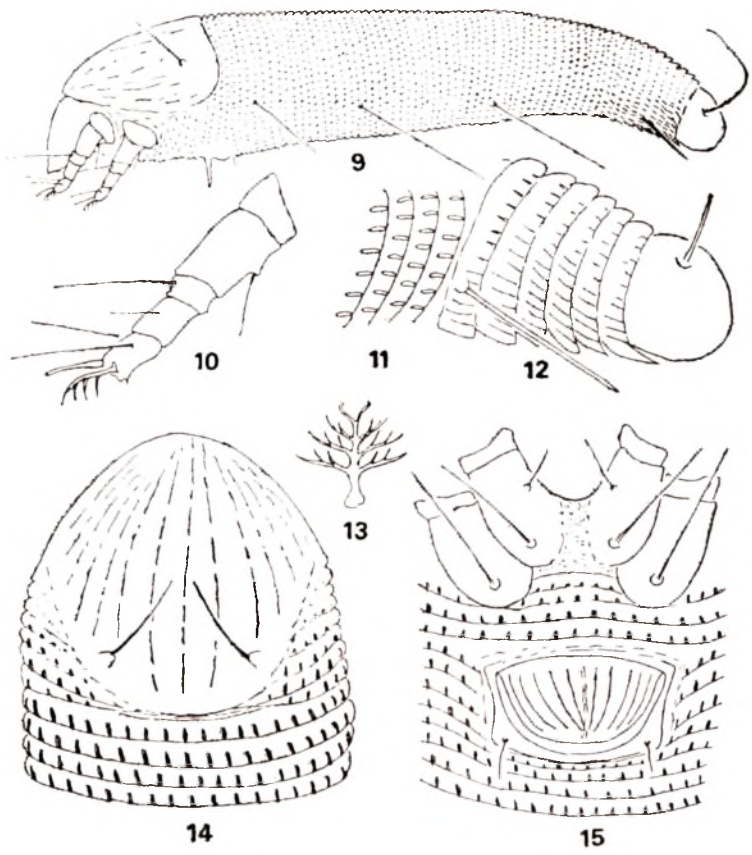
Figs. 1 to 8: *Paraphytoptus jujubae* sp. nov. 1. Side view of mite; 2. Left foreleg; 3. Side skin structure; 4. Side view of caudal end; 5. Feather claw; 6. Internal female apodeme; 7. Dorsal view of anterior end; 8. Female genitalia and coxae from below.

Remarks:

This species resembles *Paraphytoptus arceuthobii* Keifer (1952) by its 6 rayed feather claw and the lines on the female genital cover flap, but differentiated by the shield pattern and smooth coxal area. It also resembles *P. bativagrans* Keifer (1966) in its 6 rayed feather claw and the lines on the genital cover flap but may be differentiated from the latter species by the non-granular sides of shield, and smooth coxal area apart from the differences in the shield pattern.

2. Eriophyes ensifoliae, sp. nov. (Figs. 9–15)

Female: White, worm like, 210–220 long; 40–45 thick, rostrum 12 long, down curved, antapical seta 3 long. Shield 30 long, 35 wide, with a pattern of thick broken lines; median, admedians, submedians all represented by broken lines; sides of shield with scorings; dorsal tubercles just away from shield margin, 14 apart, dorsal setae 15 long, pointing inward and forward. Foreleg 26 long, tibia 5 long, tibial seta 3 long at about middle, tarsus 5 long; claw 4 long, tapering; feather claw simple, 4 rayed, hind-leg 24 long, tibia 4 long, tarsus 5 long; claw 6 long tapering. Coxae broadly joined with a broad sternal area; all three setiferous coxal tubercles present, coxal area smooth.



Figs. 9 to 15: *Eriophyes ensifoliae* sp. nov. 9. Side view of mite; 10. Left foreleg; 11. Side skin structure; 12. Side view of caudal end; 13. Feather claw; 14. Dorsal view of anterior end; 15. Female genitalia and coxae from below.

Abdomen with about 70 uniformly microtuberculate rings, microtubercles elongate, situated on the hind-margin of each ring; lateral seta 17 long on ring 9, first ventral seta 40 long on ring 19; second ventral seta 40 long on ring 37; third ventral seta thick, 10 long on ring 6 from behind, caudal seta 45 long; accessory seta absent, female genitalia 20 wide, 12 long, cover flap with 10–12 lines; genital seta 3 long.

Male: White, worm like, 190–200 long: 35–40 thick, genitalia 25 wide, genital seta 3 long.

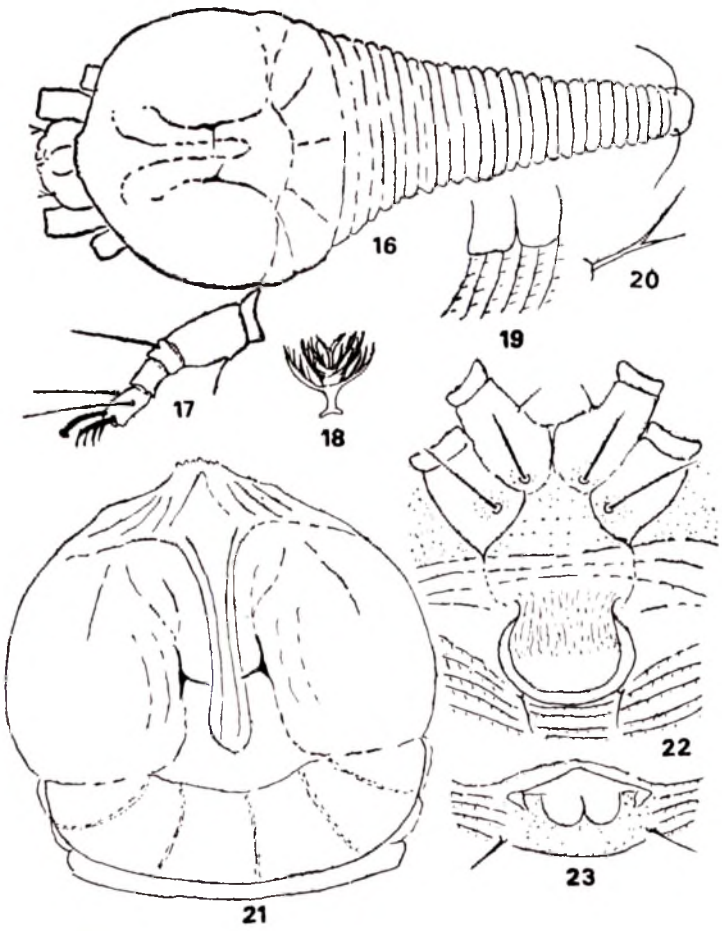
Types: Holotype ♀ marked on slide; 5 slides containing paratypes with 30 ♀♀ and 25♂♂: INDIA: TAMIL NADU: Coimbatore, Siruvani Hills. ex *Commelina ensifolia* R. Br. (Commelinaceae); 9. ix. 1987, M. Mohanasundaram Coll. (No. 552) TNAU.

Remarks: This species closely resembles *Eriophyes subbaroi* (Mohanasundaram, 1980 in its shield pattern and feather claw but could be differentiated from it by the longer second ventral setae, lesser number of longitudinal scorings on the female genital cover flap, broad sternal area between forecoxae and the elongated microtubercles both on tergites and sternites. It is differentiated from *Eriophyes rosae* (Mohansundaram, 1980) by its 4 rayed feather claw, elongated

microtubercles, longer second ventral seta, clear coxal area, and shorter genital seta; from *Eriophyes karnatakaensis* (Mohanasundaram, 1980) by its four rayed feather claw and elongated microtubercles; from *Eriophyes laurae* (Mohanasundaram, 1980) by its shield lines; four rayed feather claw; clear coxal area; longer second ventral seta: and lesser number of lines on the female genital cover flap; from *Eriophyes lantanae* (Mohanasundaram, 1980) by its shield pattern.

3. **Neodicrothrix piperae,** sp. nov. (Figs. 16–23)

Female: White, dorsoventrally flattened, wedge shaped, 130–140 long; 58–60 wide at the anterior portion; rostrum 10 long; down curved; antapical seta 6 long, bifurcate; shield 58 wide, 60 long overhanging the rostrum base; with a pattern of thin lines; median absent; admedians and sub-medians complete, joined at the posterior end and diverge anteriorly; faint lines along and on either



Figs. 16 to 23; *Neodicrothrix piperae* sp. nov. 16. Dorsal view of mite; 17. Left foreleg; 18. Feather claw; 19. Side skin structure; 20. Antapical rostral seta; 21. Dorsal view of anterior end; 22. Female genitalia and coxae from below; 23. Male genitalia.

side of dorsal tubercles and at the anterior portion of the shield; dorsal tubercles away from shield margin, 10 apart; dorsal setae 3 long pointing inward; posterior margin of shield contiguous with the fused first two tergites which bear faint divergent lines. Foreleg, 18 long, tibia 3 long, tibial seta absent, tarsus 3 long, claw 3 long, knobed at tip; feather-claw simple, 4 rayed; hind-leg 16 long, tibia 2 long, tarsus 2 long; claw 3 long; all usual setation present on both legs except for the foretibial and hind-patellar setae. Coxae with all three setiferous tubercles, coxal area almost smooth except for a few granulations around setae II and III.

Abdomen tapering; with 25 broad smooth tergites and 45 faintly micro-striated sternites; first two tergites fused dorsally with the rear shield margin; lateral seta 10 long on ring 5; first and second ventral setae absent; telosomal seta 10 long on ring 6 from behind; caudal seta 15 long; accessory seta absent; female genitalia 18 wide, 12 long, cover flap with numerous fine basal broken scorings and distally clear; genital seta 5 long.

Male: 110–115 long, 38 wide at the broadest point; genitalia 13 wide, genital seta 6 long.

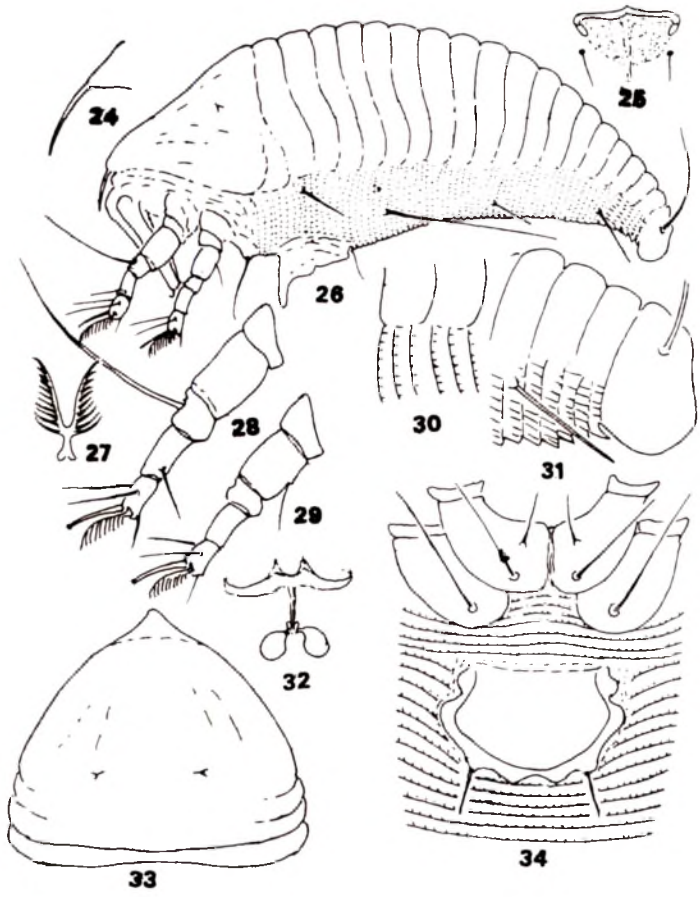
Types: Holotype ♀, marked on slide, four slides containing paratypes with 32 ♀♀ and 12♂♂, INDIA: TAMILNADU: Thadiyankudisai (Kodaikanal Hills), 24. iv. 1988. ex *Piper nigrum* (Piperaceae), S. Parameswaran Coll. (No. 551), TNAU.

Remarks: This is the second species to be described under the genus *Neodicrothrix*. It differs from the type species *N. tiliacorae* Mohanasundaram (1984) by its smaller size, smaller sized dorsal setae pointing inward, dorsal shield pattern, coverflap pattern on the female genitalia, shape of the male genitalia and smaller sized legs.

4. **Acarhynchus bamboovagrans,** sp. nov. (Fig. 24 to 34).

Female: Spindle shaped, 170–180 long; 60–65 wide. Rostrum 30 long, projecting down, chelicerae abruptly bent down near base with the oral stylet recurving near base; special sensory seta on rostrum bent down at apex. Shield broadly triangular with a thick spine like projection overhanging rostrum base; 55 wide, 50 long, shield area smooth with indefinite scorings, dorsal tubercles minute 22 apart, away from shield margin, dorsal seta 1 long. Foreleg 33 long; tibia 9 long with the tibial seta on the inner lateral side at the distal end, 12 long; tarsus 7 long; claw 9 long, tapering knobbed at tip; feather claw divided, with 10 rays in each; femoral seta absent; patellar seta 40 long; all other usual setae present. Hind-leg 30 long; tibia 7 long; tarsus 7 long; claw 9 long; tapering and knobbed at tip; femoral seta thin; patellar seta absent. A subtarsal apical seta present on all legs below the feather claw. Coxae broadly contiguous; all three setiferous tubercles present, coxal area smooth. Abdomen with 20 broad, smooth tergites and 65 narrow microtuberculate sternites; microtubercles minute; lateral seta 10 long on ring 12, first ventral seta 60 long on ring 26 extending beyond second ventral seta; second ventral seta 8 long on ring 46, telosomal seta 25 long on ring 5 from behind; caudal seta 45 long; accessory seta absent. Female genitalia 30 wide; 17 long just away from coxal base; genital cover flap smooth; genital seta 7 long, internal apodeme subacute.

Male: Spindle shaped, 170–175 long; 50 thick, male genitalia 15 wide; genital seta 7 long.



Figs. 24 to 34: *Acarhynchus bamboovagrans* sp. nov. 24. Anterior spine-like projection of shield lobe; 25. Male genitalia; 26. Side view of mite; 27. Feather claw; 28. Left foreleg; 29. Left hind-leg; 30. Side skin structure; 31. Side view of caudal end; 32. Internal female apodeme; 33. Dorsal view of anterior end; 34. Female genitalia and coxae from below.

Types: Holotype ♀ marked on slide; 5 slides containing paratypes; with 30 ♀♀ and 20 ♂♂, INDIA: TAMIL NADU: Walayar forest, 30 km from Coimbatore, 1. x. 1987 ex *Bambusa vulgaris* (Graminaceae), M. Mohanasundaram coll. (No. 549) TNAU.

Relaton to host: The mites were found on the upper surface of the leaf blades as vagrants. A large number of white cast skins were also seen. No symptoms of attack was noted.

Remarks: This is the second species to be described under the genus *Acarynchus* (Keifer, 1959). The new species is differentiated from *Acarynchus filamentus* Keifer by its shield pattern, with fine granulations on shield, the minute dorsal tubercles and setae, clear smooth coxal area and the structure and number of rays on the feather claw. It is also interesting to note that the earlier species *A. filamentus* was also recorded on a graminaceous swamp grass *Arundinaria gigantea* (Walt) Chapm. and the mites found as vagrants on the leaf blades.

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A NEW SPECIES OF *PYGMEPHORUS* KRAMER, 1877 (PYGMEPHORIDAE : ACARI) FROM SOUTH INDIA

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(*Received* 20 *July* 1988)

The paper presents the description of a new species of fungivorus saprophytic mite, *Pygmephorus keralicus* sp. nov. infesting fallen coconut buttons from Kerala, South India.

(*Key words:* *Pygmephorus*, Pygmephoridae, Tarsonemoidea, new species)

In the course of study and collection of mites associated with fallen coconut buttons, a new species of fungivorous cum saprophytic mite belonging to the genus *Pygmephorus* was encountered. The mite was studied in detail and the description and figures are presented below. The slides containing holotype and paratypes have been deposited in the collections of the Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore-641 003, India. All measurements are expressed in micrometer.

Pygmephorid mites, resembling Pyemotids have been recorded to be associated with insects, especially bark beetles (Cross and Moser, 1971) and faecal pellets of birds (Mahunka and Philips, 1978). Rack (1967) believes *Dolichocybe hippocastani* Rack to be a fungivore or a saprophage. Gurney and Hussey (1967) have cultured two species of Pygmephorids upon fungi in the laboratory. The present species described herein has been recovered from fallen coconut buttons and found to feed and breed on decaying buttons with several species of fungi growing on it.

Pygmephorus keralicus, sp. now. (Figs. 1–13)

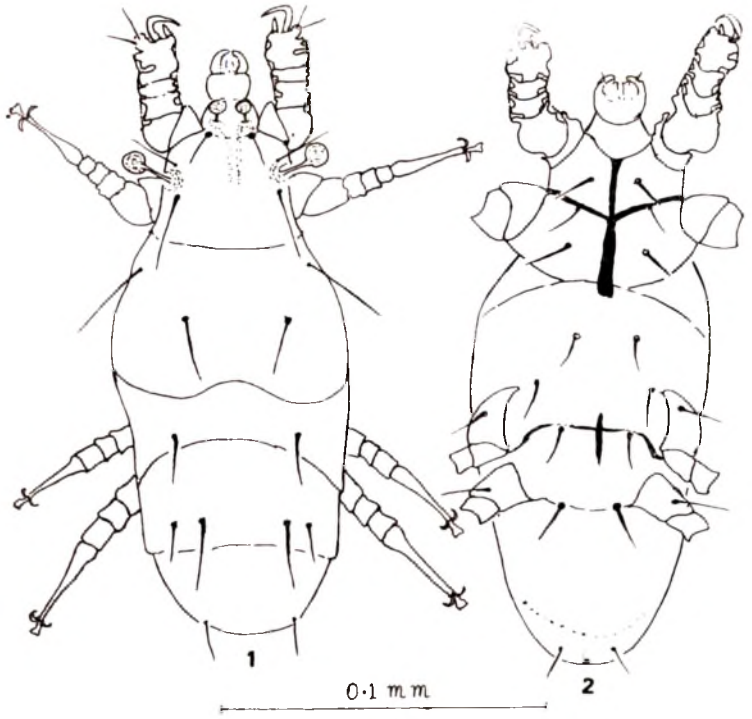
Female (*Non-gravid*): Length, 200, elongate oval; width 75, mites light tan in life, integument smooth without any markings or punctuations.

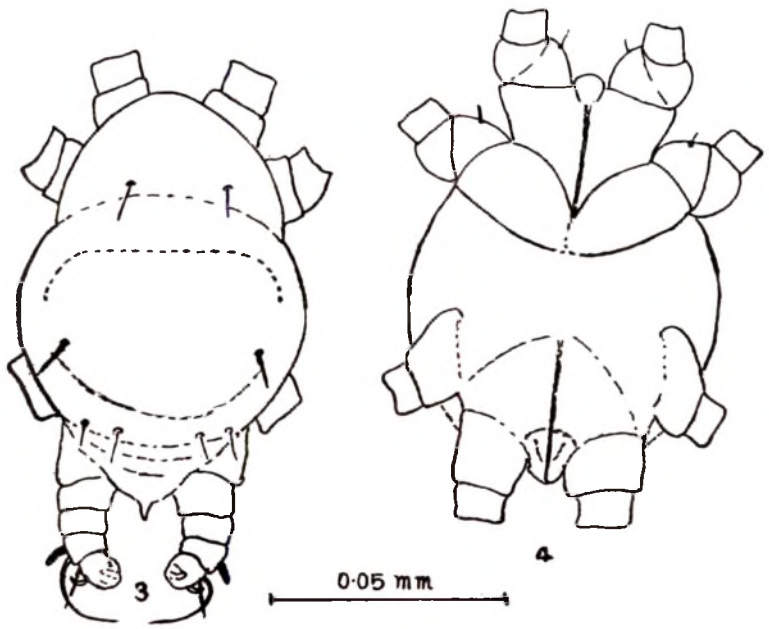
Gnathosoma: Length, 25, width, 15 with a pair of fine setae 2 long on the palp.

Propodosoma: Dorsum: Trapezoidal, anteriorly with round peritremes, and in the middle between leg I and II one pair of bulbous pseudostigmata. One pair of anterior dorsal propodosomal setae just below the peritremes, reaching the base of pseudostigmata; a second pair of dorsal propodosomal setae at the base of pseudostigmata, extending beyond the propodosomal plate. The setae are all simple and flagellate. *Venter:* The anterior ventral plate with two pairs of simple, thin, flagellate setae.

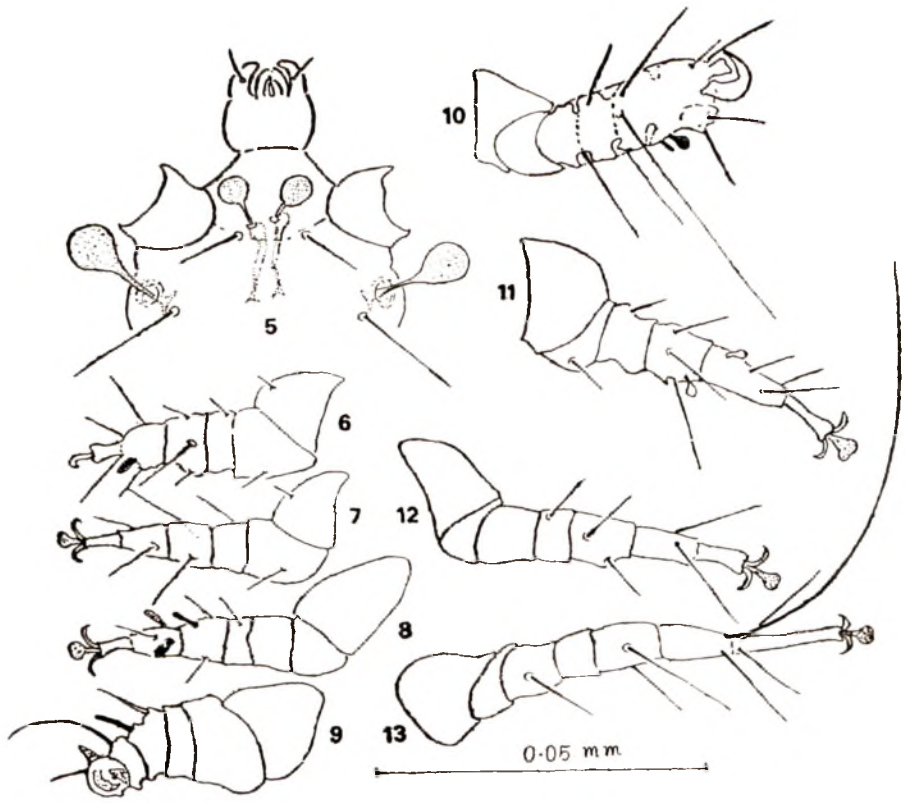
Hysterosoma: Dorsum: Represented by four distinct segments or plates, first with a pair of setae dorsally; second with one pair of setae; third with two pairs and fourth one pair at caudal end. *Venter:* The hystersomal ventral plate with five pairs of simple, flagellate setae.

Legs: Leg I 40 long; 9 wide; Leg II 40 long; 7 wide; leg III 45 long, 6 wide; leg IV 70 long, 7 wide. Setation of legs I to IV: Coxae, 0, 0, 0, 0; trochanter, 0, 1, 0, 0; femorogenu, 2, 4 (1), 1, 1, tibiotarsus, 6 (2) 6(2), 4,6.





Figs. 1–4. *Pygmephorus keralicus*: 1. Dorsal view of female; 2. Ventral view of female: 3. Dorsal view of male; 4. Ventral view of male.



Figs. 5–13. *Pygmephorus keralicus:* 5. Anterior of female; 6–9. Legs I to IV of male; 10–13. Legs I to IV of female.

Male: Length 85, width 55, weakly sclerotized, pearly white.

Gnathosoma: An anteriorly rounded lobe-like structure devoid of any setae.

Propodosoma: Dorsum: Smooth with one pair of seta.

Venter - Smooth without any apparent setation.

Hysterosoma: Dorsum. First hysterosomal plate, nearly round, smooth with three pairs of setae at its posterior end. Second hysterosomal plate band like and wrinkled; genital capsule disposed dorsally, triangular, ending in an acute process.

Venter: Apodeme of propodosoma fairly distinct, apodeme III indistinct; while apodeme IV represented as thin thickenings. No ventral setae discernible.

Legs: Leg I, 35 long, 8 wide; leg II 32 long, 8 wide; leg III 35 long, 7 wide; leg IV 28 long, 10 wide.

Leg setation I to IV: Coxae, 0, 0, 0, 0; 1, 1, 0, 0; femora, 1, 1, 0, 0; genua, 1, 1, 1, 0 tibiae, 3, 2, 1, (1); tarsi 4 (1), 2, 1(2), 2 (1).

Types: **Holotype** ♀ marked on slide and eight slides containing **paratypes** with 40 ♀♀ and 15 ♂♂ and 10 gravid females, INDIA:

KERALA: Vellayani, 17. xii. 1987, ex *Cocos nucifera* L. (Palmaceae) fallen buttons, M. Mohanasundaram Coll.

Biological observations: The gravid females, are found attached to the buttons below the perianth. The maximum size of the physogastric female was around 600 long and a maximum of 25 individuals were given birth by a female. In mature gravid females, the young ones were found actively moving inside the abdomen and males congregated on the physogastric females.

Remarks: This species resembles *Pygmephorus benetti* Cross and Moser (1971) in its general appearance of non-gravid females and males, but could be differentiated by the shape of the propodosoma, reduced dorsal setation, reduced anal setation; smooth, non-punctate dorsal integument and the leg setation.

ACKNOWLEDGEMENT

Thanks are due to Dr. E. A. Cross, North Western State College of Louisiana, Natchitoches, Louisiana for the supply of reprints on this group of mites and for the suggestions.

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DESCRIPTION OF SEXUAL MORPHS OF *TINOCALLIS KAHAWALUOKALANI* (KIRKALDY) (HOMOPTERA : APHIDIAE) FROM INDIA

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(*Received* 20 *July* 1988)

Hitherto unknown apterous oviparous female and alate males of *Tinocallis kahawaluokalani* (Kirkaldy), a member of the subfamily Drepanosiphinae, have been described.

(*Key words:* aphid, hitherto unknown sexual morphs)

The genus *Tinocallis* Matsumura 1919 has been dealt with by Richards (1967), Higuchi (1972), Raychaudhuri *et al.* (1980) and more recently by Chakrabarti (1988) who provided the taxonomic account of 6 species from the Indian subregion.

This paper describes the hitherto unknown alate male and apterous oviparous female morphs of *T. kahawaluokalani* (Kirkaldy) which chiefly infest *Lagerstroemia indica* and *Lawsonia alba* (Lythraceae) in north east India.

The materials of the new descirptions are presently deposited in the laboratory of the first author.

Material examined: India: Sikkim, Mungan, 2 alate males and 1 apterous oviparous female, 25. xi. 1984, ex *Lawsonia alba*, S. K. Mahapatra coll.

Alate male (Fig. 1): Body 1.09 mm long and 0.43 mm wide in the middle of the abdomen in the mounted specimen. Head brown, frontal prominence poorly developed. Two pairs of anterior discal and 1 pair of posterior discal hairs on distinct but low tubercles, discal hairs short and pointed. Antennae 6-segmented, 0.88 mm long, 1.24 times the body; segments I and II concolorous with head, rest of the segments pale except somewhat dusky apices; segments III, IV, V and VI with secondary rhinaria distributed as 18, 4–5, 6–7 and 2 in order; processus terminalis 0.86 times the base of the segment VI, with 1 apical and 3–4 subapical hairs. Eyes pale but ocular tubercles pigmented. Rostrum a little short of midcoxae; ultimate rostral segment 0.34 mm long and bearing 4 hairs besides the preapicals. Pronotum with single spinal and posterior lateral processi. Abdominal dorsum pale; spinal tubercles prominent on anterior tergites bearing short and spiny hairs; lateral tubercles on segments I–IV with 1 hair each; a pair of spinal hairs present on each of the segments III-VIII, those on segments III, V and VII being placed widely apart from each other. Siphunculi short, 0.06 mm long with spinular imbrications. Male genitalia well-developed. Wings normal. Otherwise as in alate viviparous females.

Measurements of one specimen in mm: Length of body 1.09, width 0.43; antenna 0.88, antennal segments III: IV:V:VI 0.41:

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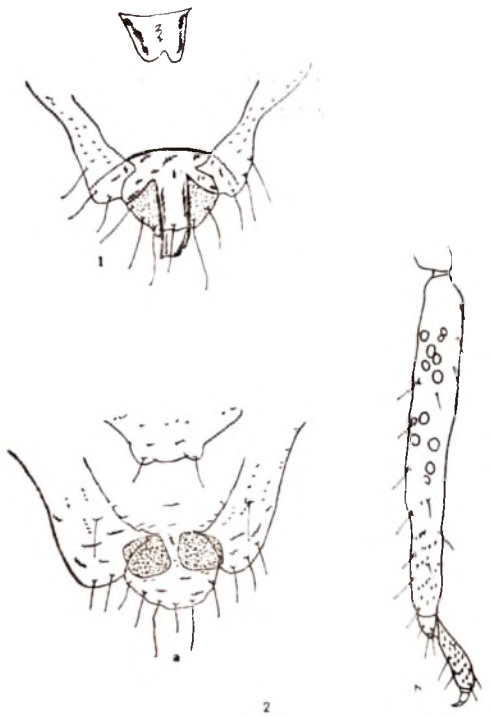

Fig. 1. Alate male : male genitalia. Fig. 2. Apterous oviparous female: a. female genitalia, b. hind-tibia showing pseudosensoria.

0.24:0.24: (0.15+0.13); u.r.s. 0.34; h.t.2. 0.08; siphunculus 0.06; cauda 0.06.

Apterous oviparous female (Fig. 2) : Body elongate, 1.34 mm long with 0.58 mm as width at the middle of abdomen. Dorsum of head deep brown, bearing 2 pairs each of anterior and posterior discal hairs on tuberculate bases, all discal hairs short and capitate. Antennae 0.73 mm long, much shorter than body, gradually distinctly imbricated anteriorly, segments I and II with 2–3 short capitate hairs; secondary sensoria absent: processus terminalis 1.11 times as long as segment VI. Unlike in alate viviparous females and alate males, thoracic tergite with paired brown hair-bearing spinal and marginal tubercles, the hairs being similar to those on head. Dorsum of abdomen with a pair of spinal tubercles on each of the tergites I - VIII, each tubercle bearing a single long capitate hair on high sockets; spinal tubercles on tergites III, V and VII widely apart and those on tergites VI and VIII are confluent; marginal tubercles present on tergites VI and VIII. Siphunculi deep brown, 0.026 mm long, without hair, anal plate indented. Hind-tibiae with 9–11 pseudosensoria on basal half (Fig. 2b). In most of the other characters, this morph is similar to the alate viviparous females.

Measurements of the specimen in mm: Length of body 1.34, width 0.58; antenna 0.73, antennal segments III : IV : V : VI 0.21 : 0.11 : 0.12 . (0.01+0.09); u. r. s. 0.07; h.t.2 0.08; siphunculus 0.026; cauda 0.04.

ACKNOWLEDGEMENTS

This work was partly financed by CSIR, New Delhi. Due thanks are extended to the Director, Zoological Survey of India (AKG) and to the Head, Department of Life Science, Tripura University for providing working facilities. Sincere thanks are also due to Dr. M. Miyazaki for critical apprisal of the manuscript.

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A NEW WHITEFLY *ALEUROCANTHUS INDICUS* SP. NOV. (ALEYRODIDAE : HOMOPTERA) FROM INDIA

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(*Received* 30 *December* 1988)

A new species of whitefly, *Aleurocanthus indicus*, infesting *Borreria hispida* in Padmanabhapuram, Tamil Nadu is described and illustrated.

(*Key words: Aleurocanthus indicus*, *Borreria hispida*, Aleyrodidae)

During the course field collection of whiteflies, a species of *Aleurocanthus* collected from *Borreria hispida* in Padmanabhapuram, Tamil Nadu, India on August 4, 1987 was found to be new to science and is described here.

Aleurocanthus indicus sp. nov. (Figures A–C)

Pupal case: Light brown; elongately oval, with little wax around the margin and dorsum; found on the under surface of leaves; 0.80–0.83 mm long and 0.57–0.61 mm wide.

Margin: Margin with a row of teeth 11–12 teeth in 0.1mm. Thoracic and, caudal tracheal pores or combs absent. Paired anterior and posterior marginal setae 12.5 and 50 μm long respectively.

Dorsal surface: Dorsum with three pairs of setae - cephalic setae 22.5 μm long, eight abdominal setae 77.5 μm long, and submarginal caudal setae 80 μm long. Dorsal surface with 24 pairs of spines -9 pairs on cephalothorax (5 subdorsal and 4 submedian), and 15 pairs on the abdomen (6 pairs on the submedian area from segments 1–6, three pairs laterad of abdominal segments 2, 3 and 5, and 6 pairs on subdorsum), 15-170 μm long. About 16 pairs of minute setae present on the submarginal area, 5 μm long.

First abdominal segment 50 μm long, second 45 μm, third and sixth 40 μm each, fourth 39 μm long, fifth 32.5 μm, eight 30 μm, seventh abdominal segment the shortest 27.5 μm long.

Vasiform orifice: Subcircular, 57.5-62.5 μm long and 55-60 μm wide; operculum rectangular 32.5 × 25 μm filling nearly two thirds of the orifice; lingula tip slightly exposed.

Ventral surface: Paired ventral abdominal setae 45 μm long and 42.5 μg apart. Antenna reaches the base of the mesothoracic leg, 80 μm long; a small seta at the base of each leg, 2.5 μm long; 5 small spines at the base of each pro– and mesothoracic leg and 6 at the base of each metathoracic leg. A pair of minute setae at the base of rostrum evident.

Host plant : *Borreria hispida.*

Material examined : **Holotype :** One pupal case mounted on slide, on *Borreria hispida*, Padmanabhapuram, 4. viii. 1987, Coll. K.

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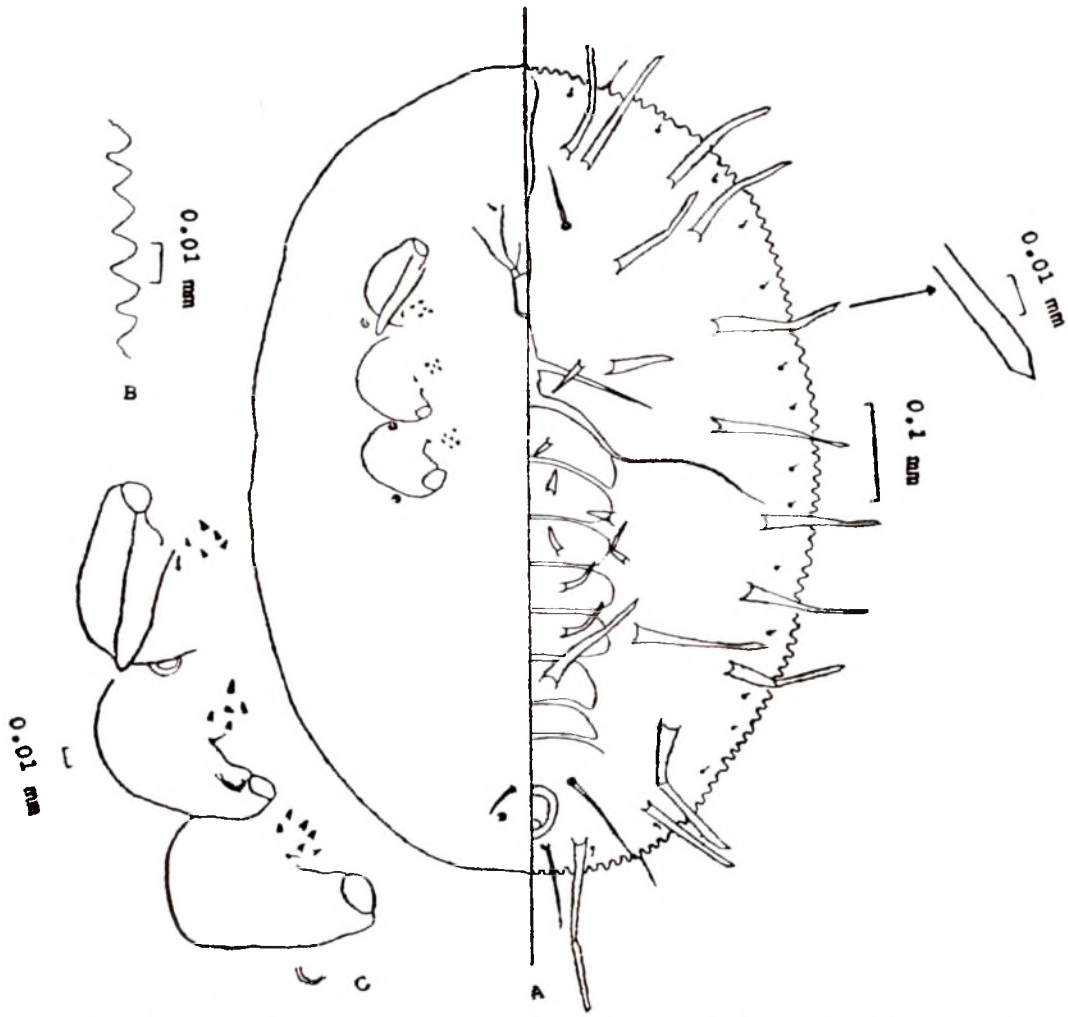

A. Pupal case of *Aleurocanthus indicus* sp. nov; B. Margin; C. Spines and seta at the base of legs.

Regu. **Paratypes** : Nine pupal cases mounted on slides bearing the same details as of holotype.

Among the species of *Aleurocanthus* known from India the pupal cases of only two species viz., *A. davidi* David and Subramaniam and *A. rugosa* Singh are light brown and transparent whereas all other species are jet black in colour (David and Subramaniam, 1976). The new species described is distinct from *A. rugosa* which has fimbriate dorsal spines but finds resemblance to *A. davidi* in the dorsal spines being pointed. It differs from *A. davidi* in having 24 dorsal spines as against 22, presence of a row of submarginal minute setae and minute short spines and a seta at the base of each leg.

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Entomon 1989 Vol. 14 No. 3 & 4 pp. 277 to 279

OCCURRENCE OF *EUCOPTACRA CEYLONICA* KIRBY (COPTACRIDINAE : ACRIDIDAE : ORTHOPTERA) IN INDIA

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(*Received* 17 *May* 1988)

While surveying the grasshoppers in Dharwad region during 1985–1986, *Eucoptacra ceylonica* Kirby was encountered for the first time. This species appears to be a new record for India. The population of this species was maximum during the month of December. *E. ceylonica* is arboricolous inhabiting bushy places with thick growth of shrubs and grasses. Adults were found feeding on the leaves of *Caesalpinia pulcherrima* (L.), *Tectona grandis* (L.) and some graminaceous weeds. The information on the taxonomic characters is included.

(*Key words*: *Eucoptacra ceylonica*, new record, epiphallus, supra-anal plate)

INTRODUCTION

The Indian fauna of Acridoidea has been studied by Kirby (1914) and Uvarov (1921, 1929). Rattan Lal and Baldev Prashad (1959) have studied the male genitalia of some Indian Acridinae. Usman and Puttarudraiah (1955) listed 49 species under 35 genera from Karnataka. Although Dharwad district with its varied agro-climatic regions is known to have a rich grasshopper fauna, no attempts have been made so far to study the occurrence of different species of grasshoppers in the region.

The survey was taken up in three different agro-climatic areas of Dharwad district namely, transitional area (Main Research Station, Dharwad), *Malnad* area (Forest Research Station, Prabhunagar) and *Maidan* area (Agricultural Research Station, Belvatgi). Regular collections of grasshoppers were made (between 10.00 to 12.00 h) at fortnightly intervals from July 1985 to June 1986.

The host plants were recorded by directly observing the feeding in fields and by providing the food plants to the enclosed adults.

To study the epiphallus, the abdominal tips of the dried specimens were cut off and boiled for five minutes in 10 percent potassium hydroxide solution and then washed with water. The epiphallus and the supra-anal plate (last abdominal tergite) were dissected out and placed in acetic acid for 30 minutes, then in carbolic acid and later in carboxylol (1:3 parts). After clearing they were mounted on slide in DPX and were dried at 40°C.

Terminology of parts:

Terminologies of the parts used in the present work are after Dirsh (1965).

Ancorae (A). A pair of processes or projections on anterior margin of dorsal surface of epiphallus.

Anterior projections (Ap). Projecting anterior ends of lateral plates of epiphallus.

Bridge (B). Middle part of epiphallus connecting lateral plates.

Epiphallus (Eph.). Sclerite located on dorsal side of phallic organ.

Furcula (F). A pair of backwardly direc-

ted appendages which overlie in a more or less forked position at the base of the supra-anal plate.

Lophi (L). A pair of processes on or near posterior end of epiphallus.

Lateral plates (Lp). A pair of plates forming sides of epiphallus.

Posterior projections (Pp). Posterior ends of lateral plates of epiphallus.

RESULTS AND DISCUSSION

During the course of survey in Dharwad region, *Eucoptacra ceylonica* Kirby was encountered the first time in this region. This species is a new record for India. Kirby (1914) described and reported the occurrence of *E. ceylonica* from Ceylon (Shri Lanka). Tandon (1976) has also quoted Kirby (1914) regarding the occurrence of this species. So far only *E. praemorsa* Stal. was known from India (Kirby, 1914).

Of the three areas surveyed, this species was found distributed in Dharwad (transitional) and Prabhunagar (moist deciduous forest) area. *E. ceylonica* was a very rare species. A single male was collected during the first fortnight of July in Dharwad, whereas a few individuals were collected in Prabhunagar from second fortnight of November to first fortnight of February. Only one population peak (3 individuals/two h) was observed, during the December indicating one generation per year.

E. ceylonica is arboricolous, inhabiting bushy places with thick growth of shrubs and grasses and in teak plantations along with *E. praemorsa* which is also reported to be arboricolous, found in dense patches of grass and bushes (Tinkham, 1940).

The adults were found feeding on the leaves of *Caesalpinia pulcherrima* (L.), *Tectona grandis* (L.) (teak) and some grasses of unknown identity. At Prabhunagar almost all the individuals were collected in the teak plantations but the defoliation of teak was negligible due to the small population. This species can be considered to be a minor pest of teak along with *E. praemorsa* which is already reported by Beeson (1928) as a pest of teak.

Study of the epiphallus indicated that it is bridge shaped with broad median bridge. Ancorae large and incurved with wide base and pointed apex. Lophi large, hook like with truncate apex. Posterior plates well developed whereas anterior plates are small but distinct (Fig. 1a).

The supra-anal plate (Fig. 1b) uniformly chitinised, attenuated with round apex. Furcula excurved and more or less chitinised. The presence of furcula, divided bridge of the epiphallus and attenuated apex of supra anal plate are the important characters of the subfamily Coptacridinae (Dirsh, 1965).

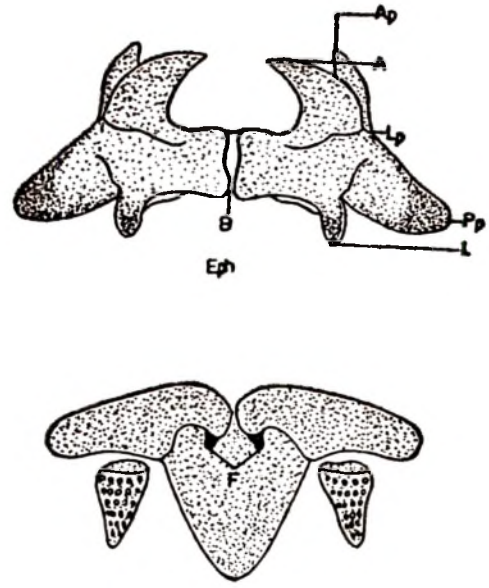

Fig. 1. *Eucoptacra ceylonica*. Epiphallus (above) and Supra - anal plate (below). A. ancorae, Ap. anterior projection, B. bridge, Eph. epiphallus, F. furcula, L. Lophi. Lp. Lateral plates.

KEY TO THE SPECIES OF *EUCOPTACRA* I. BOLIVAR

1. Pronotum rugose, hind-femur with a distinct black spot; wings hyaline yellow...*E. ceylonica.*

— Pronotum finely punctated, hind-femur without the black spot; wings hyaline, greenish towards base .....*E. praemorsa.*

ACKNOWLEDGEMENTS

The authors are grateful to Mr. J. GRANSHAW of TDRI, London, for identifying the grasshopper species and Mr. H. R. RANGASWAMY, Associate Professor, Zoology, for his help in drawing the figures.

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BRIEF COMMUNICATION

A NEW METHOD OF *CORCYRA CEPHALONICA* STAINTON MOTH COLLECTION[1]

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(*Received* 20 *July* 1988)

A mechanical device has been developed for large-scale rearing of rice moth, *Corcyra cephalonica* Stainton. The new device has increased the moth collection efficiency by 33%, reduced escape of moths by 6.17 folds, damage of adults by 100% and hazardous inhalation of scales by the worker has been eliminated.

(*Key words*: *Corcyra cephalonica*, hand - *vs* mechanical collection, rotary vacuum pump)

The rice moth, *Corcyra cephalonica* Stainton is an important laboratory host for multiplication of a number of parasitoids and predators. Presently, its rearing is tedious as moths are collected manually, which is time-consuming and hazardous due to inhalation of moth scales by the workers. To overcome this, an attempt was made to collect the rice moths with 0.25 HP high vacuum rotary pump. The details of which are presented in this manuscript.

The rice moth was reared in wooden boxes (40 cm × 30 cm × 18 cm). For moth collection, a 2 SP - 0.25 HP metrex rotary high vaccum pump was utilised. A mechanical device (Fig. 1), was fabricated with a rubber cork (4 cm × 4 cm) having two bores (1cm). In one bore 14cm long glass tube was inserted for moth collection while the second bore consisted of a 7 cm long glass tube connected with rubber tube fixed to suction hole of the pump. Other end of tube consisted of a wire mesh basket(2-4cm)for sucking the moths inside the collection tube (20 cm × 3 cm) due to vacuum of (.001 mm Hg) developed by the pump. Egg laying capacity, moth escape and mechanical damage to moths by this method was compared with hand collection method.

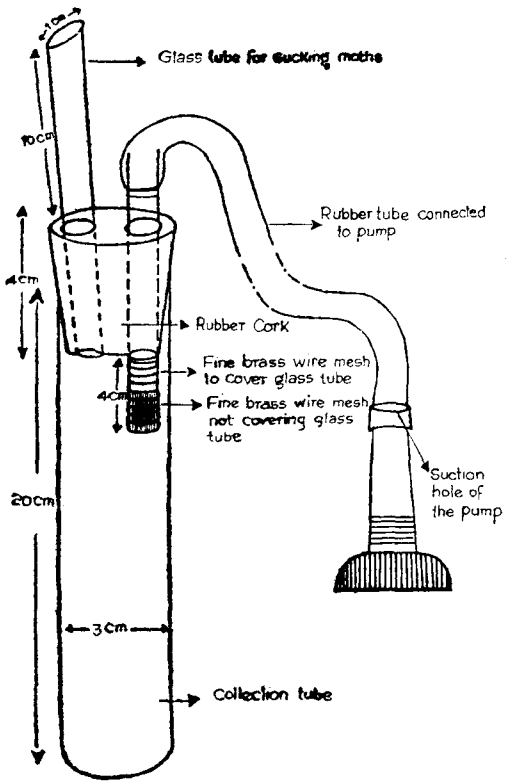

Fig. 1. Device connected to high vacuum rotary pump to collect *Corcyra* moths.

[1]Contribution No. 51001 of Biological Control Centre (NCIPM), Bangalore.

TABLE 1. Moth collection efficiency of the device.

	Mechanical collection method (MCM)	Hand collection method (HCM)
Time taken to collect 1000 moths	51.5 minutes	68.18 minutes
Number of moths escaped	29	179
Number of moths injured	0	38
Eggs collected per 1000 moths	11.2 cc	11.4 cc

The mechanical collection method (MCM) proved its superiority over hand collection method (HCM) by increasing the moth collection efficiency by 32.3%. The MCM also reduced moth escape by 6.17 times. It was observed that in HCM not more than 10 moths could be collected at one time and to prevent escape from collection tube repeated tapping was required. This in turn gave jerk to boxes resulting in more escape. In comparison in MCM even 200 to 300 moths could be collected in collection tube (20 cm × 3 cm) without jerk. Similarly, in HCM number of moths got damaged because of pushing with finger tips while in MCM no such damage was noticed. There was no difference in egg laying efficiency in both the treatments.

It is suggested that brass wire mesh fixed to glass tube should form only 2 cm – 4 cm long hanging basket as if wire mesh is tied to the hole tightly instead of creating a 2 cm – 4 cm hanging wire mesh basket, the moth scales get accumulated blocking the air suction. If length is more, moth after being sucked in collection tube hit wire mesh and get injured. After every 200–300 moths collected, mesh should be cleaned of scales.

In MCM, moth scale are collected inside the collection tube whereas in HCM scales are spread all over body of worker. Inhalation of scales for longer duration cause serious respiratory problem hence by MCM scale inhalation is eliminated. This method of collection has advantage than one described by PARSHAD (1975). In his method excessive moisture condensation was observed on rexene sheets thus inviting fungal and other disease inside chamber, besides egg laying by moths was also observed in various chambers with jowar grains. Moreover, problem of lizards entering chamber or moth scale inhalation also could not be avoided.

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PROTHORACICOTROPIC ACTION OF A JUVENILE HORMONE ANALOGUE ON NECK-LIGATED LAST INSTAR LARVAE OF *SPODOPTERA MAURITIA* BOISD. (LEPIDOPTERA : NOCTUIDAE)

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Neck-ligated last instar larvae of *Spodoptera mauritia* of various ages (day 1 to day 4) were topically treated with different doses of a juvenile hormone analogue (JHA) and the effects on larval-pupal development were studied. Neck-ligated larvae which were kept as controls survived for varying number of days and then died without pupating. None of the neck-ligated day 1, day 2 or day 3 larvae treated with JHA pupated. In contrast pupation could be induced in day 4 larvae by the application of JHA immediately or 24 h after neck-ligation. These results suggest that the prothoracicotropic action of JHA is temporally restricted to the last part of he final larval instar.

(*Key words*: juvenile hormone analogue, larval-pupal transformation, *Spodoptera mauritia*)

INTRODUCTION

Prothoracic glands (PTG) of insects are the source of a prohormone, ecdysone, which is hydroxylated in the peripheral tissues to the actual moulting hormone, 20-hydroxyecdysone. The principal regulator of the secretory activity of PTG is the cerebral neuropeptide, the prothoracicotropic hormone (PTTH; BOLLENBACHER & GRANGER, 1985). There are evidences for the control of PTG activity by secondary effectors like photoperiod (MIZOGUCHI & IZHIZAKI, 1982) temperature (MEOLA & ADKISSON, 1977), direct neural input (RICHTER & GERSCH, 1983), humoral factors such as lipoproteins (CHINO *et al.*, 1974) and hormones other than PTTH (SAFRANEK *et al.*, 1980; BEYDON & LAFONT, 1983; GRUETZMACHER *et al.*, 1984a). The most important among the secondary effectors are hormones such as ecdysteroids and the juvenlie hormone (JH; STEEL & DAVEY, 1984). In the recent years several studies on a variety of Lepidoptera have shown that in the last instar larvae, JH can either inhibit or activate the PTG depending on the developmental state (CYMBOROWSKI & STOLARZ, 1979; SAFRANEK *et al.*, 1980; HIRUMA & AGUI, 1982; TOBE & FEYEREISEN, 1983; SANTHA & NAIR, 1987). In the present study we examine the role of JH in the regulation of PTG activity during the larval-pupal development of *Spodoptera mauritia* Boisd. (Lepidoptera : Noctuidae). Last instar larvae of *S. mauritia* of various ages were neck-ligated to remove the endogenous source of both PTTH and JH. These neck-ligated larvae were treated with different doses of a juvenile hormone analogue (JHA) and the effects on larval-pupal development were studied.

MATERIALS AND METHODS

Experimental animals:

The sixth-instar larvae (last larval instars) of *S. mauritia* used in the present experiments were obtained from a laboratory stock culture reared and maintained as described previously (NAIR, 1981). The age of the sixth-instar larvae is abbreviated to day '*n*' where day '0' indicates the day of ecdysis to this instar. Under the conditions employed

the period of development of sixth instar larvae was 6 days. The larvae fed voraciously during the first three days and attained maximal body weight. The feeding larvae emptied their guts and transformed into wandering stage by the end of day 4. These larvae at the end of day 5 transformed into prepupae which pupated 24 h later on day 6.

Neck-ligations were performed on day 1, day 2, day 3 and day 4 larvae. These larvae were tightly ligated just behind the head capsule using a fine silk thread. Such larvae were designated as neck-ligated larvae.

Application of JHA:

The JHA (hydroprene; gift from Dr. G. B. Staal, Zoecon Corp., California, U.S.A.) was dissolved in acetone and diluted to obtain 1 μg, 2 μg, 5 μg, 10 μg, 50 μg or 100 μg/5 μl. Day 1, day 2 and day 3 larvae were topically treated with different doses of JHA immediately after neck ligation utilizing a Hamilton microsyringe. The neck-ligated day 4 larvae were treated with JHA either immediately or 24 h after ligation. The neck-ligated larvae which were kept as controls were treated with 5 μl acetone in a similar manner. JHA treated and control neck-ligated larvae were examined daily for pupal cuticle deposition.

RESULTS AND DISCUSSION

The results of this study reveal that neck-ligated larvae which were kept as controls showed complete inhibition of moulting irrespective of the age of he larvae at the time of ligation (Tables 1 and 2). The ligated larvae survived for varying number of days and died without pupating. Obviously this is due to the absence of both PTTH and JH which are the major factors from the head that activate the PTG.

Our results have also demonstrated that in the neck-ligated last instar larvae of *S. mauritia*, the effects of JHA on larval-pupal moulting depends on the age of the larvae at the time of treatment. Neck-ligated day 1, day 2 or day 3 larvae which were treated with JHA died as larvae after varying number of days without any developmental change (Table 1). On the other hand treatments of JHA to neck-ligated day 4 larvae accelerated the moulting process and the larvae underwent pupal development

TABLE 1. Effect of treatments of JHA to neck-ligated last instar larvae of *S. mauritia*.

Dosage (μg)	*n*	Longevity in days* (mean ± SD) and % pupated (in parentheses) of larvae neck-ligated on:		
		day 1	day 2	day 3
1	10	7 ± 1 (0)	11 ± 1 (0)	12 ± 1 (0)
2	10	7 ± 1 (0)	9 ± 1 (0)	12 ± 1 (0)
5	10	7 ± 1 (0)	10 ± 1 (0)	13 ± 1 (0)
10	10	7 ± 1 (0)	10 ± 1 (0)	12 ± 1 (0)
50	10	7 ± 1 (0)	10 ± 1 (0)	11 ± 1 (0)
100	10	7 ± 1 (0)	10 ± 1 (0)	13 ± 1 (0)
5 μl acetone	10	7 ± 1 (0)	10 ± 1 (0)	11 ± 1 (0)

* Total number of days from day 0.

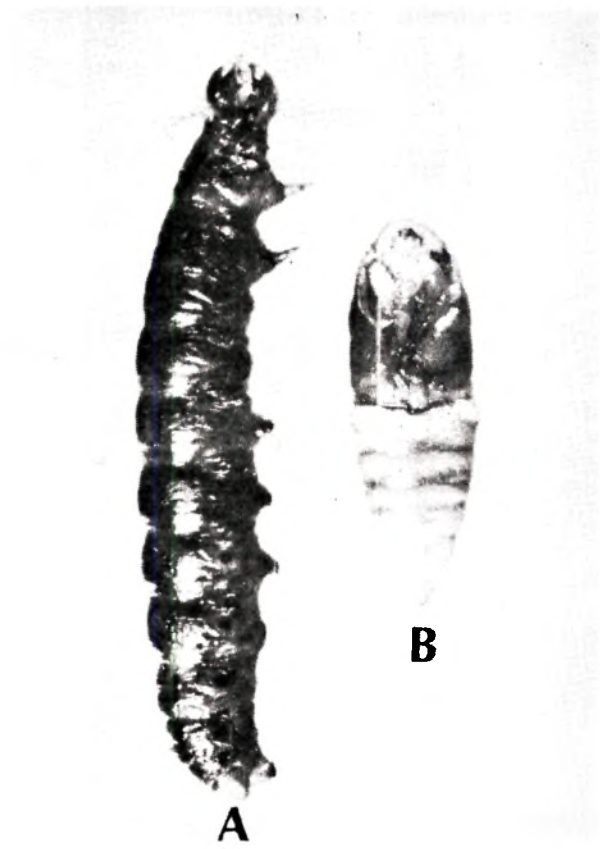
TABLE 2. Effects of treatments of JHA to last instar larvae neck-ligated on day 4.

Dosage (μg)	n	Larval period in days* (Mean ± SD) and % pupated (in parentheses) after treatment of JHA	
		Immediately after ligation	24 h after ligation
1	10	8.5 ± 0.5 (100)	8 ± 1 (93.3)
2	10	8.5 ± 0.5 (100)	8 ± 1 (100)
5	10	8.5 ± 0.5 (100)	8 ± 1 (100)
10	10	8 ± 1 (46.6)	8 ± 1 (100)
50	10	12 ± 1 (0)	8 ± 1 (100)
100	10	12 ± 1 (0)	8 ± 1 (100)
5 μl acetone	10	12 ± 1 (0)	12 ± 1 (0)

*Total number of days from day 0.

(Table 2). The pupa even though headless was otherwise normal in appearance (Fig. 1). The experiments presented here clearly show that there is a change in the sensitivity of PTG of last instar larvae of *S. mauritia* to JHA. JHA cannot activate PTG of day 1, day 2 and day 3 larvae but can activate those of day 4 larvae. These results are consistent with earlier observations on a variety of lepidopteran larvae which have shown that JH or its analogues exerts a positive effect on PTG late in the last instar larval development (HIRUMA *et al.*, 1978; CYMBOROWSKI & STOLARZ, 1979; SAFRANEK *et al.*, 1980; GRUETZMACHER *et al.*, 1984a, CYMBOROWSKI & ZIMOWSKA, 1984). Experimental studies on *Manduca sexta* indicate that JH activation of PTG may be mediated by a PTG stimulatory factor which is induced in the fat body by JH (GRUETZMACHER *et al.*, 1984b). Further these studies have led to the conclusion that high JH titer inhibits PTG early in the last instar larvae while late in the instar JH influence is reversed resulting in the activation of PTG (HIRUMA *et al.*, 1978; CYMBOROWSKI & ZIMOWSKA, 1984). Thus in the last larval instar of Lepidoptera there is a switchover in the sensitivity of PTG to JH. Our findings have further demonstated that treatments of neck-ligated day 4 larvae with high doses of JHA inhibit larval–pupal development (Table 2). These results suggest that the switchover in the sensitivity of PTG to JH may occur on day 4 and that high JH titer can prevent this switchover. By contrast all the neck-ligated day 4 larvae treated with different doses of JHA 24 h after ligation undergo normal pupal development (Table 2). It is possible that in these larvae the switchover in the sensitivity of PTG has already occurred and hence they undergo pupation.

During larval–pupal development of all the Lepidoptera examined there are two peaks in the ecdysone titer (BOLLENBACHER *et al.*, 1975; CALVEZ *et al.*, 1976; LAFONT *et al.*, 1977; DEAN *et al.*, 1980; FUJISHITA *et al.*, 1982). The first small peak of ecdysone is observed just after the first PTTH release and is believed to be responsible for initiation of wandering stage (TRUMAN & RIDDIFORD, 1974; BOLLENBACHER *et al.*, 1975; GILBERT *et al.*, 1981). JH on the other hand, shows high titer early in the last larval instar which then declines to undetectable levels by the end of feeding period. There is however a second increase in JH titer



A. Neck-ligated larva of *S. mauritia*.
B. Headless pupa obtained after treatment of neck-ligated larva with JHA.

during the prepupal stage (RIDDIFORD & TRUMAN, 1978; BEAN *et al.*, 1982). The second PTTH release along with the prepupal peak of JH activates the PTG to produce the second major increase in ecdysone titer which promotes successful larval-pupal transformaton (RIDDIFORD, 1985). The present results show that in the absence of second release of PTTH, JH can perform this function of activating PTG.

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STRUCTURAL ABERRATIONS INDUCED BY BENZYLOXY COMPOUNDS IN THE GROWTH AND DIFFERENTIATION OF TESTIS OF THE RICE MOTH *CORCYRA CEPHALONICA* (LEPIDOPTERA : PYRALIDAE)

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The role of benzyloxy compounds A13-63604 (2, 6-difluoro-N-[[4-[(3-fluorophenyl) methoxy] phenyl] methyl] benzenamine), A13-63629 (1-4-chlorophenyl)-2-methyl-3-[4-(phenylmethoxy) phenyl]-2-propene-1-one) and A13-63701 (1-[(4-methylphenyl) methoxy]-4-pentylbenzene) in the growth and differentiation of testis of the rice moth *Corcyra cephalonica* (Stainton) has been examined by topical application to 0-24 h old last instar larvae, pupae and adults with dosages of 100 μg, 50 μg, 10 μg and 1 μg per individual. Larval treatment induces the production of compact mass of cysts in the testis of resultant larvoid adults and adultoids. Among the various developmental stages of testicular cyst population, spermatid cysts are more numerous than in controls which indicates delayed differentiation of spermatozoa. In a few cases, eupyrene sperm bundles have attained giant size due to excessive elongation of tails. At times, the two developing testis-sacs fail to fuse into a sigle sac. Conversely, in the defective pupae and adultoids developed from pupal treatment, the production of testicular cysts of different kinds is inhibited. Moreover malformed and sometimes degenerating spermatozoan cysts are produced. In a few cases differentiation of even the spermatid cysts has been almost entirely prevented specially in the case of defective pupa. In most of the defective pupae the two developing testis-sacs remain separate or they are imperfectly fused into a median organ. The effect of benzyloxy compounds on spermatogenesis does not seem to be direct. Imaginal treatments with benzyloxy compound induce thin and short sperm bundles. The changes produced by these compounds showed similarity with those of terpenoid or sesquiterpenoid juvenile hormone analogues.

(*Key words*: benzyloxy compound, testis morphogenesis, aberrations, *Corcyra cephalonica*)

INTRODUCTION

Juvenomimetic effect of benzyloxy compounds on the development and metamorphosis of *Oncopeltus fasciatus*, *Tenebrio molitor*, *Spodoptera frugiperda* and *Corcyra cephalonica* has been reported (DEMILO & REDFERN, 1979; DEMILO *et al.*, 1980; DEMILO, 1984; ROYCHOUDHURY & CHAKRAVORTY, 1985). Apart from our earlier work on labial gland (ROYCHOUDHURY et al., 1988), the morphogenetic effects of benzyloxy compounds on other internal organs have received little attention of workers. The present investigation is an attempt to explore the structural derangements in the growth and differentiation of testis after larval, pupal and imaginal treatments with three benzyloxy compounds A13-63604, A13-63629 and A13-63701 in *C. cephalonica* (Stainton), a major pest of stored commodities in tropics (AYYAR, 1919; PILTZ, 1977).

MATERIALS AND METHODS

The rearing conditions of *C. cephalonica*, method of application of compounds(Table 1) to 0–24 h old last instar larvae, pupae and adults at the rates of 100 μg, 50 μg, 10 μg and 1 μg per individual were the same as described earlier (ROYCHOUDHURY & CHAKRAVORTY, 1985; CHAKRAVORTY et al., 1986). Since 1 μg could not induce any noticeable morphogenetic change in the internal organs,

[1]For correspondence.

TABLE 1. Names of three benzyloxy compounds

Code No.	Chemical name
A13–63604	2, 6-difluoro–*N*–[[4–[(3–fluorophenyl) methoxy] phenyl] methyl] benzenamine
A13–63629	1–(4–chlorophenyl)–2–methyl–3–[4–(phenyl–methoxy) phenyl]–2–propene–1–one
A13–63701	1–[(4–methylphenyl) methoxy]–4–pentylbenzene

this dose was disregarded during evaluation of results of the present investigation.

The male reproductive system of the resultant forms (larvoid adults and adultoids) was dissected out in insect Ringer's solution within 0–24 h after emergence. Defective pupae were dissected on the 8th day after treatment which corresponded to 1 day after the mean duration of control pupae. The testes of 3 day old moths after imaginal treatments were also included in the study. The tissues were fixed in Bouin-Duboscq (alcoholic Bolin's fluid) for 48 h, sectioned and stained in Masson's trichrome for histological studies. A minimum of ten individuals, collected at random from each category of experimental and control individuals, were studied in order to evaluate the effects of the benzyloxy compounds. For determining the cyst population of different cell components, randomly selected sections from testis of five individuals of an experimental/control series were studied and the cyst count was recorded (DEB & CHAKRAVORTY, 1981; ROYCHOUDHURY & CHAKRAVORTY, 1988). The data were subjected to χ^2 test.

RESULTS

Growth and differentiation of testis in control individual :

Testis of *C. cephalonica* first became visible under dissecting microscope as two extremely delicate sacs (testis sacs) in prepupa just prior to pupation. Within 12–24 h of pupal life the two testis-sacs became enclosed in a single sac. The histomorphological architecture of testis of control moth was described previously by DEB & CHAKRAVORTY (1981).

Effects due to larval treaments:

Anatomical abnormalities: In larval-imaginal intermediates or larvoid adults obtained from 100 μg, 50 μg and 10 μg treatments of benzyloxy compounds A13–63604, A13–63629 and A13–63701 (Table 2) the two developing testis-sacs, on rare occasions, failed to become enclosed in a single sac (Fig. 1). Instead, they remained wide apart. As a consequence, the two accessory glands which normally remained closely adherent, were also distinctly separate and sometimes became small and asymmetric.

Histological abnormalities: Histologically, the testes of all the larvoid adults and adultoids showed much higher number of cysts of different cell components per unit area than control series (Table 3). As a result there occurred numerical increase of cysts which were arranged compactly (Fig.2). There was no blockage in the spermiducts. Moreover, compared to the control individuals the number of spermatozoan cysts was less and that of spermatid cysts was more. In a few cases the eupyrene sperm bundles attained giant size due to excessive elongation of tails (Fig.3). The testes which failed to form a single sac showed ill developed sac and interfollicular partitions were broken or these were hardly visible under light microscope (Fig. 4). The density of cyst population was higher in such cases than in the testes of control individuals.

Effects due to pupal treatments:

Anatomical abnormalities: Treatment of benzyloxy compounds A13–63604, A13–

63629 and A13–63701 to pupae induced the occurrence of a good percentage of defective pupae or non-emerged adultoids (Table 2). In all the defective pupae the testes failed to develop normally. Either the two developing testis sacs remained separate or they were imperfectly fused into a median organ. The most noteworthy feature was the presence of externally visible conspicuous lobes which could never be found in normal testis either before or after their fusion. The size of testis was noticeably small. The accessory glands and ejaculatory duct were also reduced in length.

Histological abnormalities: Severe histological derangements which were common to both defective pupae and adultoids, were :

TABLE 2. Percentage of intermediate forms obtained after treatments of three benzyloxy compounds A13-63604, A13–63629 and A13–63701 on 0–24 h last instar larvae and pupae of *C. cephalonica*.

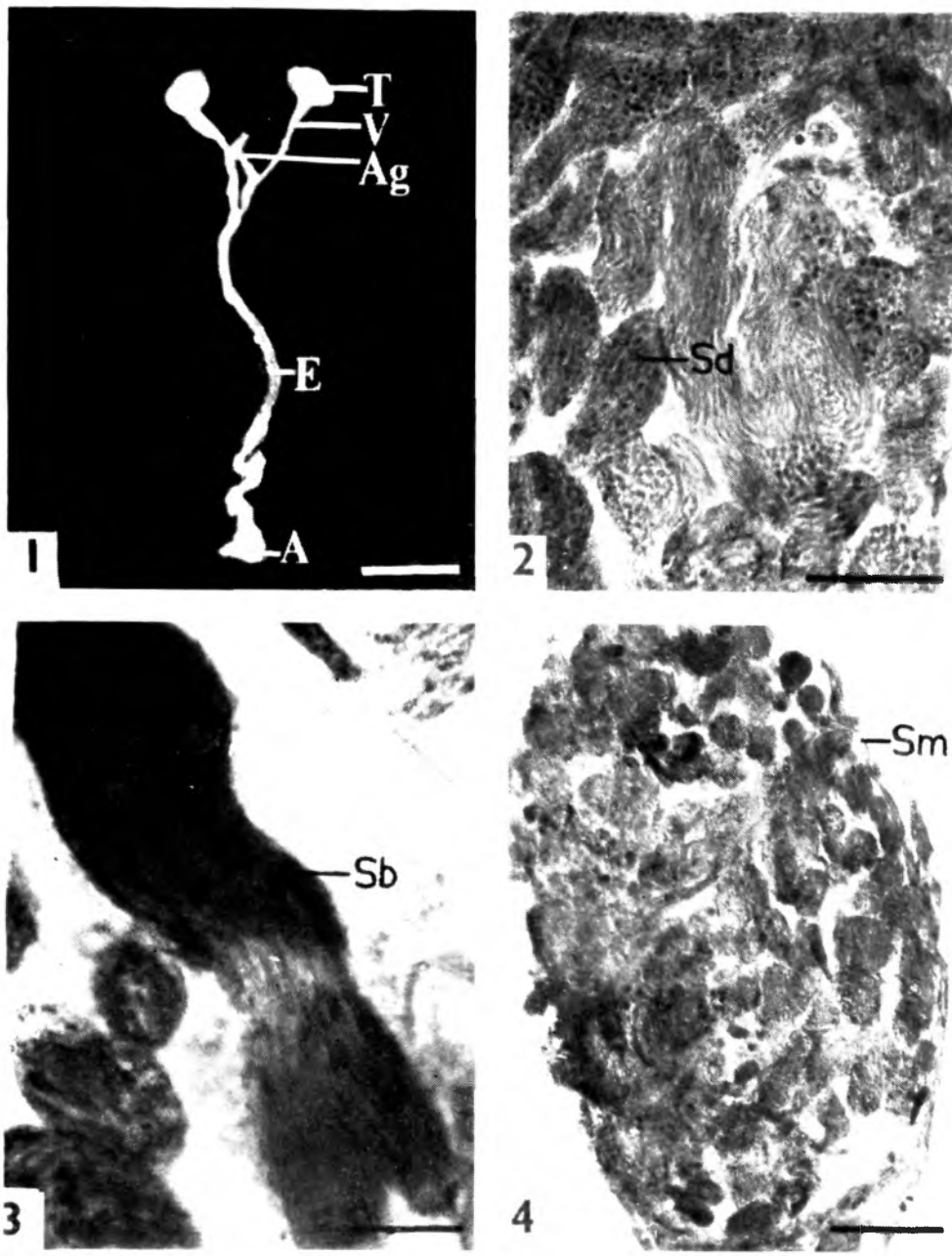
Stage treated	Dose (μg/individual)	Intermedite forms (%)		
		A13–63604	A13–63629	A13–63701
Last instar larvae	100	26.31 L–I	22.85 L–I	44.44 L–I
		21.05 A	28.57 A	14.44 A
		11.84 NA		
	50	11.42 L–I	21.66 L–I	37.33 L–I
		17.14 A	36.66 A	29.33 A
		47.14 NA		
	10	2.85 L–I	25.00 L–I	24.00 L–I
		7.14 A	26.66 A	46.66 A
		67.14 NA		
	1	82.00 NA	78.33 NA	80.00 NA
	Control	83.33 NA	83.33 NA	83.33 NA
Pupae	100	44.73 A	37.50 A	30.00 A
		23.68 DP		12.50 DP
				10.00 EP
	50	51.50 A	34.28 A	36.10 A
		17.10 DP		16.65 DP
				2.75 EP
	10	53.84 A	33.33 A	46.87 A
		19.23 DP		9.37 DP
				3.12 EP
	1	70.00 NA	69.22 NA	76.66 NA
	Control	80.00 NA	80.00 NA	80.00 NA

Larvoid adults or laraval-imaginal intermediates (L–I); adultoids (A); defective pupae or non-emerged adultoids (DP); extra pupal instars (EP) and normal adults (NA).

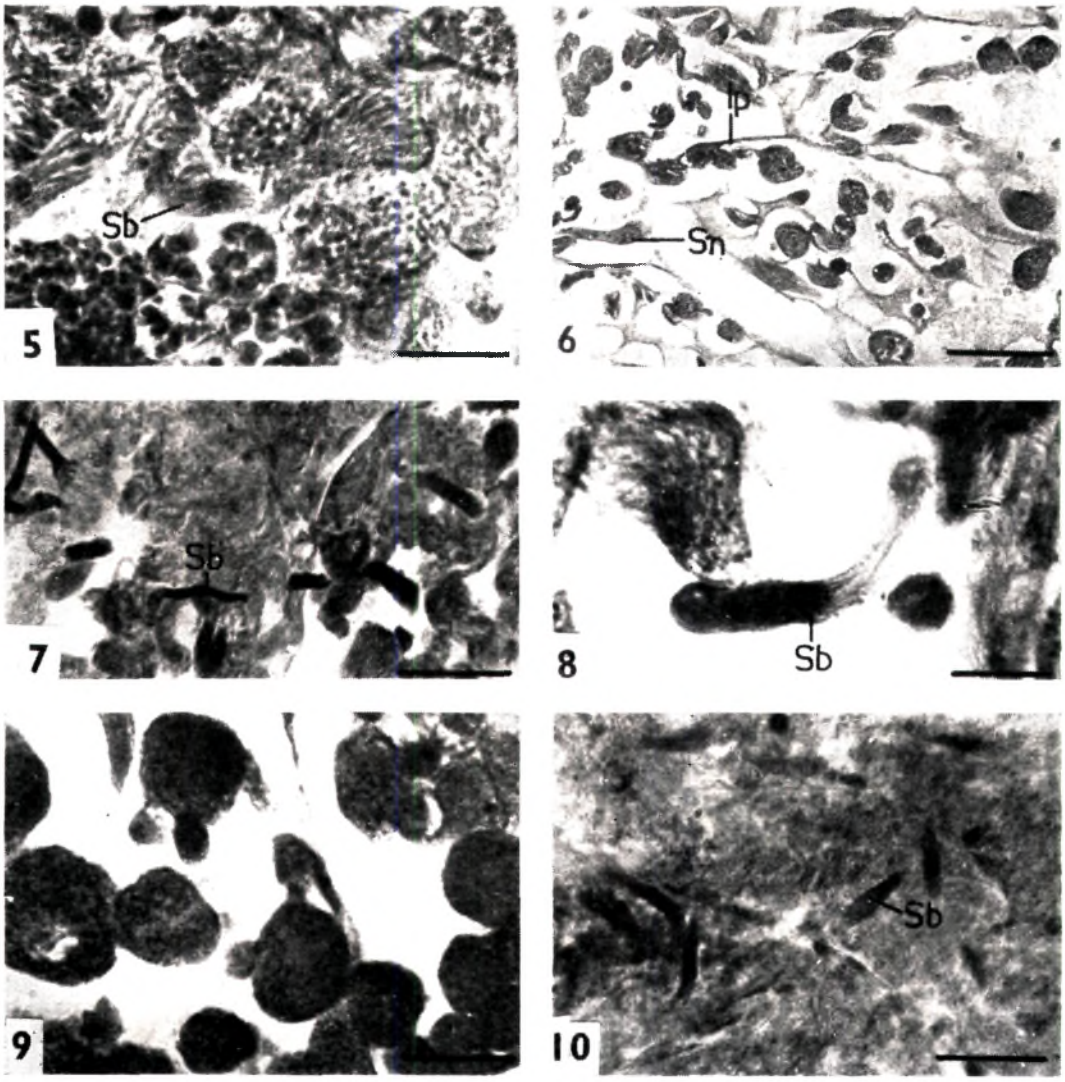
TABLE 3. Data of testicular cyst count (A) after larval and pupal treatments with three benzyloxy compounds A13–63604, A13–63629 and A13–63701; (B) control and (C) normal pupa of age corresponding to treatment time in *C. cephalonica*.

Stage treated	Dose μg/ individual)	Cyst count/0.7 mm² (one unit area) Mean±SE	Different kinds of cysts (%)		
			Spermato-zoan cysts	Spermatid cysts	Spermatogo-nial and sper-matocytic cysts
	(A) A13–63604				
Last instar larva	100	62.70 ± 6.97	18.50	67.46	14.03
	50	58.70 ± 5.13	16.18	66.95	16.86
	10	57.20 ± 4.83	16.25	62.58	19.40
Pupa	100	33.50 ± 5.04	37.91	28.05	33.73
	50	34.80 ± 4.93	33.90	31.60	34.48
	10	37.30 ± 4.33	34.58	29.22	36.19
χ^2value d.f. 2		4.42	1.60	4.24	0.11
Significance		$P>0.05$	$P>0.05$	$P>0.05$	$P>0.05$
	A13–63629				
Last instar larva	100	70.80 ± 4.62	12.14	71.75	13.41
	50	64.30 ± 4.73	19.28	66.56	15.70
	10	58.90 ± 3.80	20.20	61.46	18.33
Pupa	100	34.00 ± 4.95	35.00	30.88	34.11
	50	36.30 ± 3.90	31.95	32.78	35.26
	10	38.50 ± 3.85	32.98	33.76	33.24
χ^2value d.f. 2		11.02	4.28	14.06	0.14
Significance		$P<0.01$	$P>0.05$	$P<0.001$	$P>0.05$
	A13–63701				
Last instar larva	100	74.90 ± 3.88	17.89	66.88	15.22
	50	72.00 ± 4.62	16.80	68.05	15.13
	10	65.70 ± 4.31	17.35	64.07	18.56
Pupa	100	29.30 ± 3.06	34.47	32.76	32.76
	50	32.30 ± 3.00	34.67	31.26	34.05
	10	34.50 ± 2.87	32.75	33.62	34.50
χ^2value d.f. 2		9.51	2.34	6.49	0.91
Significance		$P<0.01$	$P>0.05$	$P<0.05$	$P>0.05$
	(B)				
Last instar larva	Control	51.66 ± 3.62	21.71	59.39	18.90
Pupa	Control	46.50 ± 3.88	30.82	44.08	25.10
	(C)				
Pupa	Normal	30.01 ± 2.46	2.65	32.23	65.12

Degrees of freedom (d.f.)



Figs. 1–4: Male reproductive system of a larvoid adult obtained due to 100 μg of A13–63629 treatment on larva, two developmental testis-sacs could not fuse into a single sac, scale bar 1mm. (2–4) Sections of testes of larvoid adults obtaind due to treatment on larvae. (2) due to 50 μg of A13–63604, high density of testicular cysts of which spermatid cysts were preponderant and compactly arranged, scale bar 50 μm; (3) due to 10 μg of A13–63701, a giant sperm bundle, scale bar 25 μm; (4) due to 50 μg of A13–63629, ill developed sac and invisible interfollicular partitions in testis which failed to become enclosed in a single sac, scale bar 100 μm. T – Testis sac, V – Vas deferens, Ag – Accessory gland, E – Ejaculatory duct, A – Aedeagus, Sd – Spermatid, Sb – Sperm bundle, Sm – Sac.



Figs. 5–10 : Sections of testes of defective pupae, adultoids and normal imagines obtaind due to treatment of pupae and imagines. (5) defective pupa due to 100 μg of A13-63701, most of the cysts underwent necrosis, scale bar 50 μm; (6) defective pupa due to 10 μg of A13-63604, populaton density of malformed cyst was comparatively low, interfollicular partitions were broken and presence of a very few spermatozoan cyst, scale bar 100 μm; (7) adultoid due to 10 μg of A13-63629, presence of reduced size and malformed sperm bundles, scale bar 50 μm; (8) adultoid due to 10 μg of A13-63701, a single reduced size malformed sperm bundle, scale bar 25 μm; (9) adultoid due to 10 μg of A13-63604, thin cyst population and all the cysts were round, scale bar 50 μm; (10) normal imagine due to 100 μg of A13-63629, short size and malformed sperm bundles scale bar 50 μm. Ip – Interfollicular partition, Sn – Spermatozoan, Sb – Sperm bundle.

the interfollicular partitions were thin, all the testicular follicles were loosely filled up with cellular elements, but their differentiation up to the stage of sperm cysts showed variation; in a few cases, the major area of each follicle was filled up with necrotic cell components of testis (Fig. 5), the necrotic cell elements were poorly stainable with Masson's trichrome; in all the experimental series the number of cysts of all kinds per unit area was lower than that in normal and control individuals (Table 3), so the cysts were loosely arranged. Abnormalities typical of defective pupae, were : the sac of testes were ill developed, interfollicular partitions were broken and either total absence or presence of only very few mature sperm cysts (Fig. 6). Abnormalities produced in adultoids were: reduced size, malformed sperm bundles (Figs. 7, 8) and presence of small, perfectly spherical cysts of spermatids and spermatozoa (Fig. 9).

Effects due to imaginal treatments:

Anatomical abnormalities : Benzyloxy compounds A13-63604, A13-63629 and A13-63701 when applied to imagines failed to produce any gross morphological change in the testis.

Histological abnormalities: Important histological abnormalities were : reduced size of the testis, malformed and deeply stained sperm bundles (Fig. 10).

DISCUSSION

The present investigation demonstrates that all the three benzyloxy compounds A13–63604, A13–63629 and A13–63701 are able to interfere with the morphogenesis of male reproductive system and thereby produce noteworthy anatomical as well as histological derangements in the growth and differentiation of testis. This property of the tested non-terpenoid compounds is not surprising because these are also regarded as potent insect JH mimics (DEMILO & REDFERN, 1979; DEMILO et al., 1980; DEMILO, 1984). The same concept may explain the failure of fusion of two developing testes-sacs and, the asymmetry of the two widely separate accessory glands found after larval and pupal treatments. In *Heliothis virescens* the testicular growth and differentiation and, the fusion of paired testes have been, however, shown to be the function of ecdysteriods (LOEB et al., 1984, 1986). Striking morphological deformities produced by juvenoids in testis, vas deferens and accessory gland have been recorded in *Dysdercus cingulatus* by JUDSON et al. (1978) and in *Chrysocoris stollii* by ROYCHOUDHURY et al. (1987).

The change is the number of cysts per unit area caused by larval and pupal treatments has similarity with the findings of DEB & CHAKRAVORTY (1981) recorded after hydroprene treatment in *C. cephalonica*. SZOLLOSI (1975) has not observed any effect of juvenoids on spermatogenesis in *Locusta migratoria migratorioides* and in *Schistocerca gregaria* when applied during last larval life. Alterations in spermatogenesis through the action of juvenoids in different insects have been noticed by CANTACUZENE & SEUREAU (1970). It has been reported from the studies on *Spodoptera littoralis* that juvenoids when applied to the larvae may produce malformed and degenerate sperm (GELBIC & METWALLY, 1981) or inhibit spermatogenesis (YAGI & KURAMOCHI, 1976). This is possible because in noctuid moth growth and differentiation of testis begin in the early larval stage. DUMSER & DAVEY (1974), from their studies on *Rhodnius prolixus* have come to the conclusion that juvenoids induce the prolongation of spermatogenetic process. This may be the reason for the giant size of some of the malformed sperm bundles obtained in the present investigation. Further, the formation of a larger quantity of male germinal tissue following larval treatment in the present investigation may not indicate increased

fertility because the spermatozoan cyst population was noticeably low.

Production of numerous derangements like malformed, irregular, degenerate cyst population and inhibition of growth and differentiation of testis, which have been recorded in the present work after pupal treatment, are in conformity with the results of LANDA & MATWALLY (1974) in *Trogoderma granarium* and GELBIC & METWALLY (1981) in *Spodoptera littoralis*. LEVIATAN & FRAILANDER (1979) have reported that a high titre of juvenoid inhibits the elongation of the nucleus during spermiogenesis and this may be the possible explanation for the smaller size of the sperm bundles and spherical cysts observed in the present species.

AMBIKA & PRABHU (1978) have demonstrated in *D. cingulatus* that juvenoids stimulate transformation of spermatocytes into spermatids and sperm. They have suggested that the influence of corpus allatum hormone (CAH) on spermatogenesis may be direct. This possibility cannot be ruled out because in the present investigation in which there is no uniformity of effects on the experimental individuals even if the same dose was employed. However, SZOLLOSI (1975) has stated that the effects of juvenoids on spermatogenesis is not direct, but the sterility of males is caused by the inhibition of differentiation of imaginal spermiducts. Direct effect of juvenoids on sepermatogenesis is not demonstrable due to the difficulty in making a distinction between the direct effects of hormone upon the germinal tissue and the effects produced by hormone upon the supportive tissues (KOEPPE et al., 1985). However, it is clear from the present work that all the three benzyloxy compounds when applied to larvae delay the morphogenesis of testis, as is evident from the presence of large number of spermatid cysts in the larvoid adults and adultoids. Further, when these benzyloxy compounds are applied to pupae, the growth and differentiation processes within the testis have almost been completely inhibited and for this reason, a decreased number of cyst population has been recorded in defective pupae and adultoids.

The production of deeply stained sperm bundles of smaller size after imaginal treatment shows that these compounds are effective in the imagines because it was observed that juvenoids caused a distinct reduction in the mobility of sperm (SHUKLA, unpublished observation quoted from SRIVASTAVA, 1981).

It is, thus, evident that the functional expressions of the three benzyloxy compounds A13–63604, A13–63629 and A13–63701 have similarity with the terpenoid or sesquiterpenoid juvenile hormone analogues. All these results suggest that a kind of male sterility could be induced by benzyloxy compounds when applied to the larvae, pupae (ROYCHOUDHURY, 1985) and imagines of *C. cephalonica* (CHAKRAVORTY et al., 1986).

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MORPHOGENETIC ALTERATIONS IN THE LABIAL GLANDS DURING DEVELOPMENT AND METAMORPHOSIS OF DIAPAUSING RICE STEM BORER LARVAE OF *SCIRPOPHAGA INCERTULAS* (LEPIDOPTERA, PYRALIDAE) UNDER HORMONAL STRESS

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Neck ligature-cum-decapitation and application of juvenoids (hydroprene and methoprene) at the initial phase of diapause of the last instar larvae of *Scirpophaga incertulas* (Walker) produces irregularities in the degeneration of the secretory part (middle and posterior divisions) of labial gland. This consists of changes in the histomorphological architecture mainly in lumen diameter, wall thickness, nuclear and cytoplasmic materials and secretory content of the glands of the extra larval instars (produced after neck ligature-cum-decapitation and juvenoid treatment) and larval-imaginal intermediates (produced after juvenoid treatment) which develop after early diapause breaking. The posterior division is severely affected. Some of the changes are intermediate in the way of larval-pupal transformation while others are early pupal and unique and probably have resulted from graded inhibition of cytolytic changes through the influence of prothoracic gland hormone (PTGH). The histological changes in the larvae which remain in the diapause state for some time and do not undergo moulting after thoracoabdominal ligature are similar to control late larval (diapausing) cytolytic changes; these manifestations are possibly due to relatively low titre of PTGH to juvenile hormone (JH) caused by the deprivation of hormonal source. Though there is an apparent increase in the length of labial glands of the extra larval instars developed after juvenoid treatments this cannot be ascribed to the stimulation of the activity of glands. Failure to spin larval shelter by most of the resultant forms obtained after application of juvenoids may be due to premature termination of diapause and early initiation of metamorphosis or may be due to the inhibitory effect of the interaction between JH and moulting hormone as suggested by the ligature experiments.

(*Key words*: histomorphology, *Scirpophaga incertulas*, diapause larvae, development, metamorphosis, labial gland, ligature, hydroprene, methoprene)

INTRODUCTION

Our knowledge on the endocrine influence on structure, growth and activity efficiency of the labial gland, as well as their cytolytic changes during larval-pupal transformation is restricted only to a few lepidopteran insects (AKAI et al., 1981; SEHNAL et al., 1983; SEHNAL & MICHALIK, 1984; SEHNAL, 1985). Moulting hormone (MH) initiates the degeneration of labial gland and, once this process has been initiated by MH, the degeneration of the gland may continue even in the presence of juvenile hormone (JH) (KAWAI, 1978) which otherwise normally prevents degeneration (GRZELAK et al., 1982). The existing morphogenetic information on labial glands in the diapausing immature insects is far from complete. The present paper deals with hormonal control of growth, metamorphic changes and function of the secretory part of labial glands caused by ligature and juvenoid-treatment of the diapausing larvae of rice stem borer *Scirpophaga incertulas* (Walker).

MATERIALS AND METHODS

Diapausing rice stem borer larvae of *S. incertulas* were collected by incising the

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tillers of rice stubbles (GHOSH et al., 1985; ROYCHOWDHURY et al., 1985). Ligature was applied in three ways: neck ligature, neck ligature-cum-decapitation and thoraco-abdominal ligature (ROYCHOUDHURY et al., 1985). The control larvae were not ligated. Juvenoids hydroprene (ZR-0512 or ethyl 3,7,11-trimethyl-2,4-dodecadienoate) and methoprene (ZR-0515 or isopropyl 11-methoxy-3,7,11-trimethyldodeca-2.4-dien-oate) were applied topically in acetone solution at the dosage of 100 μg, 10 μg and 1 μg per individual. Each individual received 1 μl solution containing the required amount of the chemical and control larvae received 1 μl of acetone per individual. Control, ligatured and JHA treated larvae were reared individually(CHAKRAVORTY et al., 1985; ROYCHOUDHURY et al., 1985). Neck ligature or 1 μg juvenoid treatment failed to induce any notable morphogenetic change in the labial glands.

The different categories of control and experimental individuals from which labial glands were dissected out and studied were: control larvae of early, mid (with no histologically distinct feature) and late phases of diapause, extra larval instars, adultoid larvae, prepupae and pupae (Table 1). The glands, after a thorough examination *in situ* were dissectd out from the 0–24 h old ultimate resultant forms. Similarly, the glands were dissected out from control individuals at larval (early spinning), mid (spinning) and late (post-spinning) phases of diapause), prepupal and pupal stages (post-diapause). The comparison between experimental and control glands was made with reference to the particular region of the glands of different individuals. The morphometric data were based on a minimum of 10 individuals for each of the categories and measurements were recorded at the maximum point. For histological purpose,

TABLE 1. Categories of individuals of *S. incertulas* from which labial glands were studied.

Experiment	Days after ligature/ treatment	Stages of individuals	Abbreviated nomenclature of the morph	Expt. no.
Neck ligature-cum-decapitation	10	Extra larval instars after 1 extra moult	L–L	L1
Thoracoabdominal ligature	33	Last instar larvae corresponding to late diapause stage. These larvae did not undergo any moult.	NML	L2
Hydroprene treatment	28	Extra larval instars after 1 extra moult	H1–1	H1
	13	Larval-imaginal intermediates (adultoid larvae)	H1–i	H2
Methoprene treatment	7	Extra larval instars after 1 extra moult	M1–1	M1
	39	Larval–imaginal intermediate (adultoid larvae)	M1–i	M2
Control	5	Last instar larvae at early diapause stage	Cle	C1
	35	Last instar larvae at mid diapause stage	Clm	C2
	70	Last instar larvae at late diapause stage	Cll	C3
	80	Prepupae	Cppu	C4
	86	Pupae	Cpu	C5

the tissues were fixed in alcoholic Bouin's solution for 48 h, sectioned and stained in Masson's trichrome. The histological measurements were taken from the glands of 5 individuals of each category and at least 10 random sections of each division of the gland were measured in order to eliminate localized disorder or artifacts at the site of treatments, if any, from the over-all disorders recorded during evaluation of the effects of ligature and juvenoids. Data were subjected to statistical treatment by analysis of variance technique.

RESULTS

Structure, secretory efficiency and morphogenetic fate of labial glands in control individuals:

The labial glands of diapausing larvae of *S. incertulas* were somewhat cylindrical, transparent and provided with a smooth outline. Structurally and functionally each gland could be distinguished into anterior (non-secretory duct, KAFATOS, 1976), middle and posterior divisions (AKAI, 1983). There was no external demarcation between middle and posterior divisions. The histological structure of the secretory part of the gland of different metamorphic stages (Figs. 1–6) was similar to that of the labial gland of *Chilo auricilius* (GHOSH & CHAKRAVORTY, 1987).

The larvae of *S. incertulas* sometimes took shelter inside leaf-cases built with their salivary secretion (SEN & CHAKRAVORTY, 1970). The diapausing larvae were always enclosed within white silken webs or cocoons spun with the secretion of their labial glands. The activity of the labial glands in the larvae at mid-diapause stage had been found to be at its peak. Usually the external opening (exit hole) of the emergence path of the cocoon was spun with fine web. This path was tubular: often one or two horizontal septa were webbed by the larva in this tubular path to make the cocoon water proof (PATHAK, 1968). After completing the construction of this pupal shelter the glands underwent cytolytic changes and almost within 3–days of pupal life they were completely degenerated.

Effects of ligature:

The labial glands of extra larval instars (L–L) and of unmoulted larvae (NML), resulting from neck ligature-cum-decapitation and thoracoabdominal ligature respectively at early diapause phase, showed striking histoarchitectural disorders. The middle division of the gland was not much affected but the posterior division was seriously affected as compared to controls.

In middle division of the gland, both L–L and NML stages showed some common histological abnormalities; these were: lumen diameter reduced (Table 2), lumen contained old secretion (Fig. 7). Abnormalities typical of L–L stage were : wall thickness normal (Table 2) and increased number of deep stained nuclei. Abnormalities produced in NML stage were : wall thickness increased (Table 2). nuclear and cytoplasmic materials were stained homogeneously in some places.

The histological aberrations observed in posterior division of the gland common to both L–L and NML stages were : lumen diameter reduced (Table 2), deep stained nuclei of variable shape, presence of empty spaces in the seretory part (Figs. 8, 9), degeneration of the gland started (Fig. 10), nuclear materials and cytoplasm started disintergration (Fig. 11). Abnormalities typical of L–L stage were : reduced wall thickness (Table 2), degeneration has advanced greatly and externally irregular nature of wall (Fig. 12). Abnormalities produced in NML stage were : length

TABLE 2. Data (Mean ± SE) of wall thickness and lumen diameter (in μm) of the secretory portion of labial gland of experimental and control individuals after ligature and juvenoid treatments in *S. incertulas*.

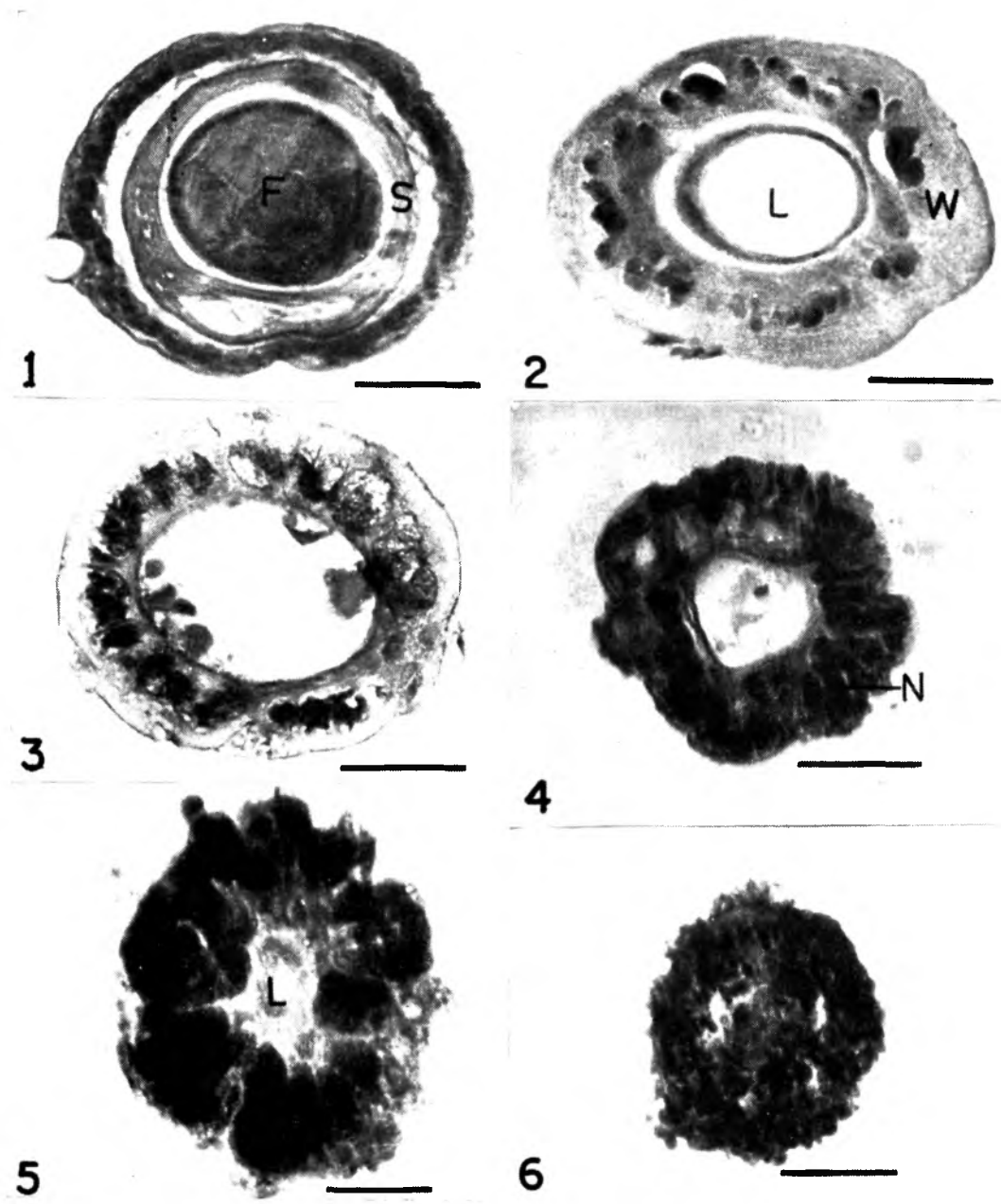
Morph studied	Expt. no.	Middle division of the gland		Posterior division of the gland	
		Wall thickness	Lumen diameter	Wall thickness	Lumen diameter
L–L	L1	21.50 ± 2.96 (19–29)	75.00 ± 9.86 (56–93)	33.60 ± 7.21 (26–47)	42.30 ± 12.91 (23-59)
NML	L2	28.20 ± 1.94 (24–31)	87.90 ± 14.06 (66–108)	50.00 ± 3.03 (45–53)	58.00 ± 9.90 (45–79)
Hl–1	H1	28.20 ± 3.34 (24–34)	89.80 ± 11.58 (62–106)	64.40 ± 7.75 (52–74)	61.60 ± 5.23 (54–72)
Hl–i	H2	28.32 ± 5.39 (19–36)	68.18 ± 20.41 (44–90)	43.16 ± 7.91 (36–56)	38.68 ± 8.04 (28–52)
Ml–1	M1	31.50 ± 2.30 (28–36)	100.80 ± 9.14 (87–118)	50.52 ± 4.75 (44–61)	30.00 ± 4.74 (20–37)
Ml–i	M2	14.77 ± 1.61 (12–17)	56.11 ± 6.21 (44–63)	33.57 ± 4.93 (21–43)	52.76 ± 8.63 (38–68)
Cle	C1	22.40 ± 3.71 (18–29)	105.90 ± 6.37 (92–116)	47.60 ± 8.07 (31–57)	97.20 ±12.72 (58–118)
Cll	C3	27.00 ± 4.83 (18–36)	62.40 ± 9.72 (48–78)	49.20 ± 8.04 (36–60)	46.80 ± 5.00 (39–54)
Cppu	C4	27.40 ± 2.40 (26–32)	59.00 ± 2.04 (54–62)	49.60 ± 4.82 (42–58)	35.20 ± 7.08 (24–46)
Cpu	C5	31.60 ± 4.56 (26–42)	44.60 ± 4.92 (38–54)	38.40 ± 6.58 (30–46)	22.80 ± 4.95 (18–30)
C.D. of L1, L2, C1, C3, C4, C5	at 1%	4.514	11.032	8.617	12.253
	at 5%	3.381	8.264	6.455	9.179
C.D. of H1, H2, C1, C3, C4, C5	at 1%	5.126	14.542	9.515	10.393
	at 5%	3.840	10.894	7.128	7.786
C.D. of M1, M2, C1, C3, C4, C5	at 1%	4.438	8.047	8.777	10.188
	at 5%	3.324	6.028	6.575	7.632

C. D. = Critical difference. Range values are in parentheses.

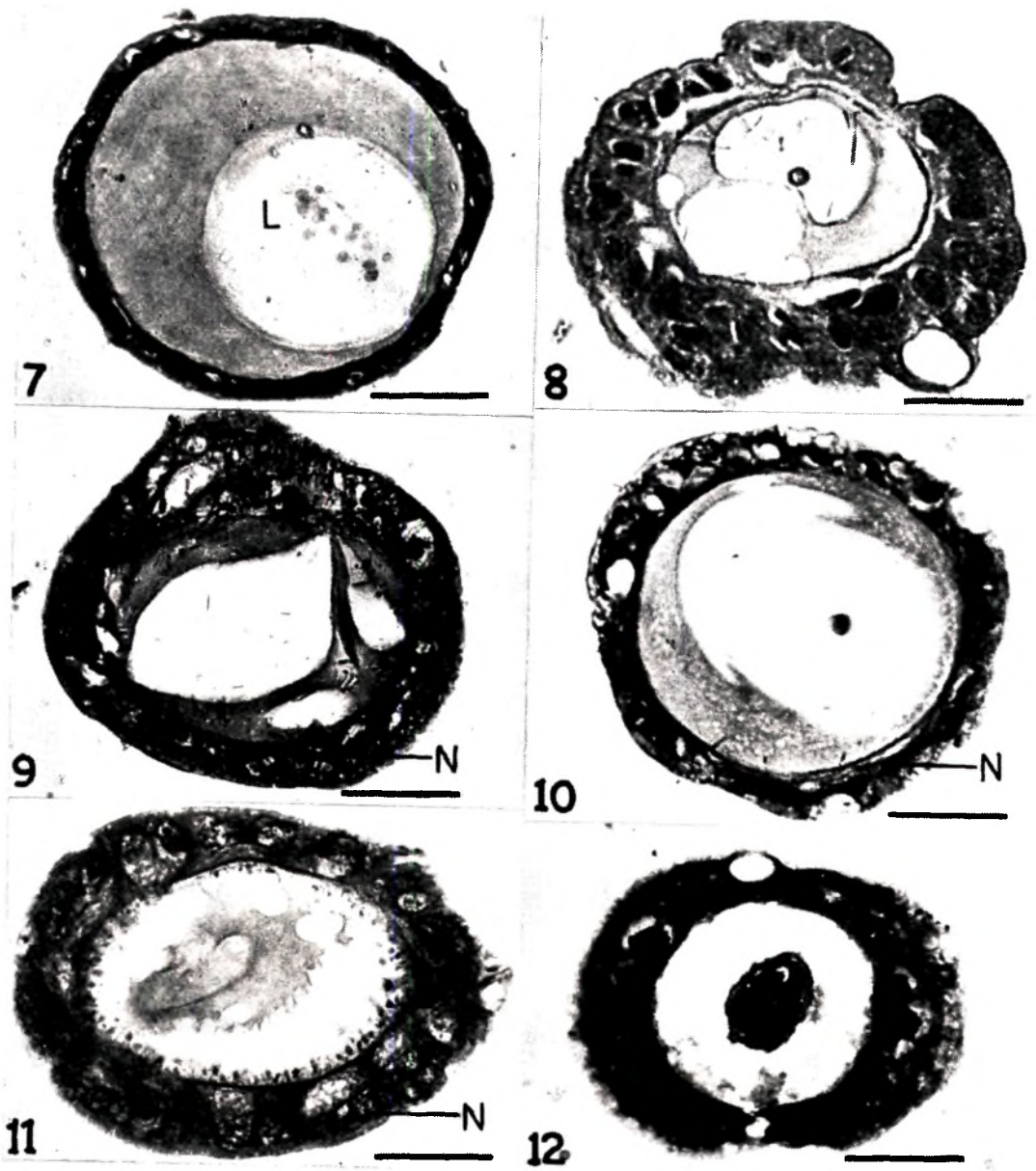
reduced, wall thickness increased (Table 2) and irregular shaped fibroin.

Effects of juvenoids :

Both hydroprene and methoprene produced similar effects in the middle division of the labial glands of Hl-1 and Ml-1 stages obtained after 100 μg treatments; these were : wall thickness increased and lumen diameter decreased (Table 2). There was no gross histomorphological defects. The histoarchitectural faults common to both juvenoid treatments in the posterior division of the glands of these forms were : wall thickness inreased and lumen diameter decreased (Table 2), irregular cell proli-



Figs. 1–6: Cross sections of labial glands of control forms. (1) Middle division of Cle stage (inner fibroin, F; outer ring sericin, S); (2) Posterior division of Cle stage (thick wall, W; narrow lumen, L); (3) Posterior division of Cll stage (no secretion); (4) Posterior division of Cppu stage (nuclear materials, N as deep stained bodies); (5) Middle division of Cpu stage at 1-day old (cytoplasm underwent maximum lysis and reduced lumen, L); (6) Middle division of Cpu stage at 2-day old (absence of lumen). Scale bar = 100 μm.



Figs. 7–12: Cross sections of labial glands of experimental forms produced after ligature. (7) Middle division of L–L stage (lumen contained old secretion L; increased number of deep stained nuclei); (8) Posterior division of L–L stage (reduced lumen, irregular nature of wall and presence of empty spaces in the secretory portion); (9) Posterior division of NML stage (alveolar cytoplasm, decreased number of nuclear materials, N and presence of empty spaces in the secretory portion); (10) Posterior division of NML stage (nuclear materials, N and cytoplasm on the way of degeneration); (11) Posterior division of L–L stage (cytoplasm and nuclear materials, N started disorganization); (12) Posterior division of L-L stage (reduced lumen, degeneration of the gland progressed much and irregular nature of wall). Scale bar = 100 μ m.

feration and abnormal thickening of gland wall, either total absence or presence of little secretion and alveolar cytoplasm (Fig. 13), destruction and abnormal clumping of nuclei and cytoplasm (Fig. 14). Abnormality typical of hydroprene treatment was : nuclear components fused and formed a ring (Fig. 15). Abnormalities produced after methoprene treatment were : deep stained and increased number of nuclei; cytoplasm and nuclear materials started disintegration (Fig. 16).

The important abnormalities produced in the middle division of labial glands of Hl-i and Ml-i stages after 10μg treatments were: wall thickness and lumen diameter decreased (Table 2); and presence of deep stained nuclei. The common histological faults recorded in the posterior division of the labial glands of these forms were : reduced wall thickness and lumen diameter (Table 2), secretion absent or reduced in quantity; size and number of nuclei reduced (Figs. 17, 18). Abnormalities typical of methoprene treatment were: presence of large deep stained nuclei (Fig. 19), local thickening of gland wall (Fig. 20), nuclear and cytoplasmic materials started disintegration (Fig. 21).

Ratio and correlation co-efficient (r) of body length and gland length:

The control larvae, prepupae and pupae differed significantly in metric characters of labial glands. The ratio of mean body length (lb) and mean labial gland length (11 g) in control prepupae and pupae was always greater than 1.0 ($\leq$1.31). In all control larval stages and in intermediates the ratio was below 1.0 ($\geq$0.59 in hydroprene treated forms and $\geq$0.57 in methoprene treated forms). The correlation co-efficient (r) between lb and 11g of control individuals was significantly positive at the early phase of diapausing larvae ($P<0.05$) and at the post-diapause pupal stage ($P<0.001$) but this was not significant at the midphase of diapausing larvae and post diapaused prepupal stage. Among the intermediate forms only in Ml-i the correlation co-efficient was significantly positive ($P<0.05$) (Table 3).

On secretory efficiency of the gland:

Secretory effiiciency of labial gland was generally reflected in the size of cocoon, length of the gland and the amount of secretion present in the lumen. Hydroprene and methoprene failed to induce high activity of labial gland in the diapausing larvae of *S. incertulas*. As compared to control cocoon, the size of the cocoons spun by adultoid larvae (Hl-i and Ml-i) were much smaller and those spun by extra larval instars (Hl-1 and Ml-1) were almost equal. The amount of secretion present in the glands of both adultoid larvae and extra larval instars was either remarkably poor or the glands ceased their secretory activity. Moreover, most of the experimental larvae failed to pupate and could not complete the construction of pupal shelter.

DISCUSSION

The diapausing larvae of *S. incertulas* after neck ligaturing-cum-decapitation and JH application at the initial phase of diapause, undergo moulting and pupation or attained next morph significantly earlier than the control larvae (GHOSH *et al.*, 1985; ROYCHOUDHURY et al., 1985). Though larvae (NML stage) with thoraco-abdominal ligature die at the diapause state without moulting, maintain their diapause for a considerable period (ROYCHOUDHURY et al., 1985).

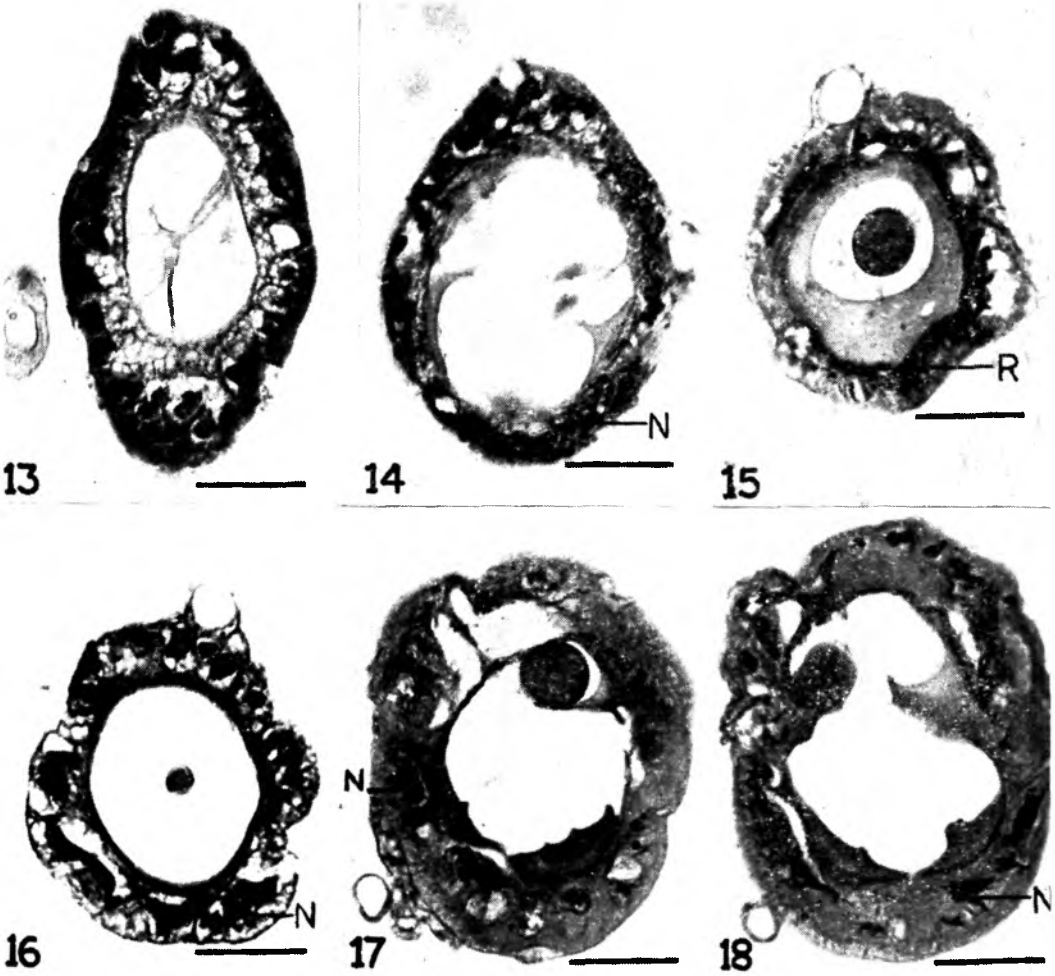
Although the L-L stage is purely larval (ROYCHOUDHURY et al., 1985) and Hl-i and

TABLE 3. Data (mean ± SE) of length of body (lb) and labial gland (llg) obtained after application of juvenoids hydroprene and methoprene in *S. incertulas* and ratio between the two (mean lb/mean llg).

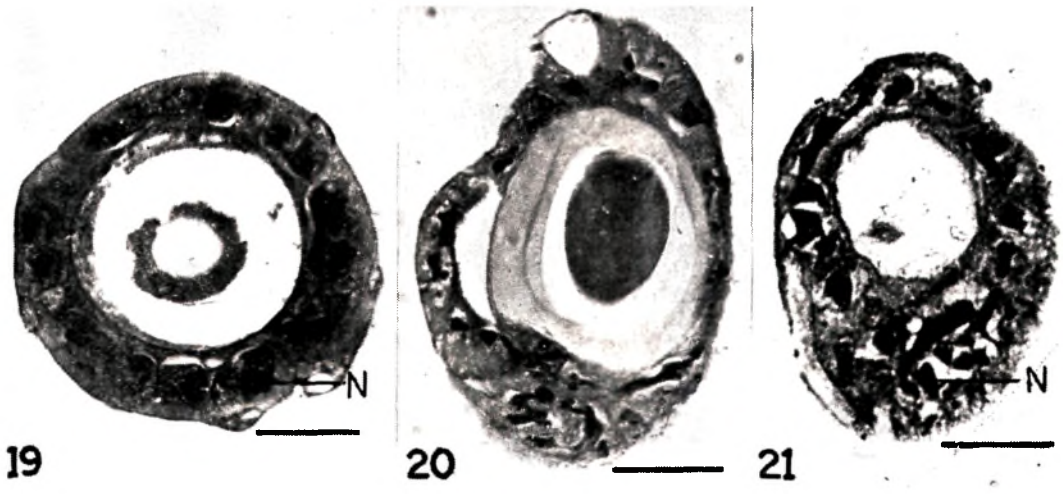
Morph studied	Expt. no.	Length of body (mm)	Length of labial gland (secretory part) (mm)	Ratio	value of r
H1-l	H1	11.30 ± 2.10 (8–13)	19.20 ± 2.85 (13–25)	0.50	0.284
H1-i	H2	9.40 ± 0.80 (8 – 10)	14.80 ± 1.54 (13 – 16)	0.63	2.154
M1-l	M1	10.10 ± 1.70 (9 – 13)	17.80 ± 3.28 (14 – 24)	0.57	0.326
M1-i	M2	9.20 ± 0.74 (8 – 10)	13.40 ± 2.05 (11 – 17)	0.69	0.727
Cle	C1	12.50 ± 1.11 (10 – 14)	15.00 ± 1.26 (12 – 17)	0.83	0.636
Clm	C2	11.80 ± 1.32 (10 – 14)	13.60 ± 1.10 (12 – 15)	0.87	0.355
Cll	C3	10.60 ± 1.01 (9 – 12)	11.80 ± 0.97 (10 – 13)	0.89	.520
Cppu	C4	10.00 ± 0.63 (9 — 11)	8.60 ± 0.48 (8 — 9)	1.16	0.208
Cpu	C5	9.20 ± 1.16 (8 — 11)	7.00 ± 0.89 (6 — 8)	1.31	0.958
C.D. of H1, H2, C1, C2, C3, C4, C5	at 1%	1.506	1.864		
	at 5%	1.131	1.400		
C.D. of M1, M2, C1, C2, C3, C4, C5	at 1%	1.336	2.057		
	at 5%	1.003	1.545		

CD = Critical difference. Range values are inside parentheses.

Ml-i stages are half larval and half imaginal in external morphology (GHOSH et al., 1985), the histomorphology of the labial gland shares characters of both Cppu and Cpu stages. This is possible because the prothoracic gland (PTG) which secretes ecdysone or prothoracic gland hormone (PTGH), remains unaffected in the ligated individuals and thus influences the kinetics of growth, function and metamorphic changes of the labial glands in total absence or presence of very low titre of corpus allatum hormone (CAH). This kind of morphogenetic admixture also indicates that there has occurred a kind of hormonal imbalance, and this may be due to the result of juvenilising and prothoracotropic (PTTH) effects of JH (SIEBER & BENZ, 1980) after termination of diapause by exogenous JHA. PTGH, besides its control over the activity, growth and degeneration of labial glands (SHIMURA, 1983), has yet another important role in induction, maintenance and termination of diapause (DENLINGER, 1985).



Figs. 13–18: Cross sections of labial glands of experimental forms produced after juvenoid treatment. (13) Posterior division of HI-1 stage due to 100 μg of hydroprene (absence of secretion and with alveolar cytoplasm); (14) Posterior division of HI-1 stage due to 100 μg of hydroprene (destruction, abnormal clumping of nuclei, N and cytoplasm); (15) Posterior division of HI-1 stage due to 100 μg of hydroprene (nuclear components fused and formed a ring, R); (16) Posterior division of MI-1 stage due to 100 μg of methoprene (cytoplasm and nuclear materials, N started disintegration); (17) Posterior division of HI-i stage due to 100 μg of hydroprene (little secretion and reduced number of nuclei, N); (18) Posterior division of MI-i stage due to 10 μg of methoprene (little secretion and reduced nuclear materials, N). Scale bar = 100 μm.



Figs. 19-21: Cross sections of labial glands of experimental forms produced after juvenoid treatment. (19) Posterior division of Ml-i stage due to 10 μg of methoprene (presence of large deep stained nuclei, N) (20) Posterior division of Ml-i stage due to 10 μg of methoprene (localised thickening of gland wall); (21) Posterior division of Ml-i stage due to 10 μg of methoprene (reduced lumen, L both nuclear materials, N and cytoplasm started disintegration). scale bar = 100 μm.

The development of glands in NML stage, maintaining diapause state, is almost identical to that of the glands of isolated abdomens of *Galleria mellonella* as found by SEHNAL & MICHALIK (1984). MAEKAWA (1979) has reported that in allatectomized or in thoracic–ligatured penultimate instar of *Bombyx mori* autolysis of labial glands can be observed within a short period. The reduction in length of the labial glands of NML stages may be due to partial autolysis of the gland cells (SEHNAL & AKAI, 1982).

The histomorphological derangements recorded in some cases of the present investigation, suggest histolysis and degradation of labial glands. These derangements may be the result of graded inhibition of cytolytic changes (CYMBOROWSKI & SEHNAL, 1980) or may be due to autodegradation of labial glands (TASHIRO et al., 1968) caused either by PTGH (in case of L-L stage or by the proportionately low titre of PTGH to JH (in case of NML stage) or by the exogenous juvenoid (in case of Hl-l, Ml-l, Hl-i Ml-i stages). Further, it has been observed that autolysis of labial glands has progressed much in L-L stage. In NML stage the abdomen possibly contains lower amount of PTGH than what is required for histolysis. However the absence of brain stimulus may have a role in the induction of lysosome formation upon which depends the autophagosomes that engulf portions of cytoplasm with protein synthesising organelles (SEHNAL & MICHALIK, 1984). In a few individuals of Hl-l stage, the formation of deeply stained ring in the cytoplasm of posterior division of labial gland might have been the result of extrusion of nuclear contents into the cytoplasm during degradation (DEB & CHAKRAVORTY, 1982). Similar situation has been encountered also at the time of autodegradation of posterior silk gland of *B. mori* (TASHIRO et al., 1968). An overall response of exogenous JH, independent of the developmental stage, is the protection of labial glands from degeneration (GRZELAK et al., 1982). Thus,

through the regulation of PTG activity and hence the MH titre, the exogenous JHA brings a change in the temporal programme of cellular degeneration of labial gland during metamorphosis. Moreover, overdose of the juvenoid tends to conserve larval nature of wall architecture and lumen content. Thus, as a result of interaction between such two-fold actions of the juvenoid, several kinds of cellular polymorphism becomes inevitable. GAREL (1983) has suggested that "silk developmental programme" is regulated as a sub-larval programme and that silk glands are the specific target tissue for JH and not for PTGH.

The reduction in wall thickness of labial glands in some cases of L-L stage (neck ligature-cum-decapitation) is not in disagreement with the observations of SEHNAL & MICHALIK (1984) made during development of decapitated last larval instar of *G. mellonella* because in the present species reduction has occurred without larval-pupal transformation but only at diapause-breaking (larval-larval moult).

In the present study, the treated juvenoid is the only determining factor since all other factors have common influence in determining the maetamorphic and functional characteristics of the labial glands in experimental and control individuals. Results of ligature experiments, with particular reference to the kind of intermediate forms and their structural variations, are supplementary evidences of the hormonal influences on the metamorphosis and functions of labial gland. The different properties of juvenoids (GAREL, 1983) are probably concerned with the hormonal regualtion of morphogenesis and function of labial gland during metamorphosis of insects.

Both the juvenoids, especially in higher doses, have a kind of toxic effect on the labial glands of *S. incertulas*. This is evident from the various lethal actions on the glands like destruction and abnormal clumping of nuclei and cytoplasm, irregular cell proliferation and abnormal thickening of gland wall, stoppage of secretion and reduction of lumen volume. Such toxic effects occur in some of the Hl-1 and in all Ml-1 stages. The labial glands of some larvae of Hl-1 stage which have not undergone such damaging effects, maintain normal features and undergo normal metamorphic changes during laraval-pupal (defective pupae, GHOSH et al., 1985) transformation.

The existence of a critical stage of endocrine influence on the correlation between the length of body and length of labial gland during diapause period of control insects, as recorded earlier (GHOSH & CHAKRAVORTY, 1987), is not only evident in *S. incertulas* but more pronounced in early phase treatments when the diapause has terminated with the change of morph (Hl-i and Ml-i stages). Thus, the early phase of diapause in *S. incertulas* is also sensitive to a change in hormonal titre.

From the thickness of wall and diameter of lumen of the intermediate forms and control individuals, the funtional efficiency of the gland can be projected with some degree of accuracy. The measurements in some cases though increased significantly from controls or even showed lb/l1 g ratio below 1.0, do not indicate increased efficiency of the gland because it is not reflected in the histoarchitecture of the secretory surface.

Failure to spin larval shelter by most of the resultant forms after application of hydroprene and methoprene may be due

to premature termination of diapause and early initiation of metamorphosis (GHOSH et al., 1985) or may be due to the inhibitory effect of the interaction between JH and MH as indicated in the present ligature experiments. From the present investigation with ligature exeriments it is clear that in the larvae of rice stem borer *S. incertulas*, after diapause breaking, the activity, growth and degeneration of labial glands are controlled by PTGH after the preceding effect of cephalic neurohormonal factor stops (ROYCHOWDHURY et al., 1985) Thus, the morphogenesis of labial gland and silk synthesis are under multidirectional influence of juvenoids (GHOSH & CHAKRAVORTY, 1987).

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EFFECT OF COLD STORAGE ON THE EMERGENCE AND SURVIVAL OF THE ADULT EXOTIC PARASITOID, *LEPTOMASTIX DACTYLOPII* HOW. (HYM., ENCYRTIDAE)

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A study was conducted to store the mummies and adults of an exotic parasitoid *Leptomastix dactylopii* How. at constant temperature of 5°, 10° and 15°C and 70–80% RH in order to be assured of huge populations at the proper time for release against *Planococcus citri* (Risso). Results indicated that 5° and 10°C were highly detrimental for emergence and survival of *L. dactylopii*. No adults emerged from stored mummies and more than 75% of the adults did not survive at these temperatures. *L. dactylopii* could tolerate 15°C for a shorter period when stored as mummies compared to adults. Females were more susceptible to cold temperatures. An increase in the duration of storage has resulted in the reduction of emergence, survival of adult in the storage and longevity of stored adults. Out of three temperature regimes, 15°C was found to be ideal for storing mummies over adults in all respect at 70–80% RH.

(*Key words*: *Leptomastix dactylopii*, storage, *Planococcus citri*)

INTRODUCTION

Leptomastix dactylopii How. (Hym., Encyrtidae) is a specific, solitary endoparasitoid of citrus mealybug, *Planococcus citri* (Risso). It was released in citrus orchards and proved highly effective in controlling *P. citri* on the Island of Procida (ZINNA, 1960), in Italy (LUPPINO, 1979), and in India (KRISHNAMOORTHY & SINGH, 1987). Under certain situations, the very high reproductive potential of *P. citri* favourably creates damaging populations before limited number of parasitoids become sufficiently active. For this reason and as well to curb the heavy mealybug populations in a newer environment, it may be necessary to release large number of parasitoids to obtain adequate control of the pest in shorter period. To ensure a sufficient parasitoid supply at the proper time for release, it may be helpful to develop and store parasitoids.

Contribution No. 207/88 of I.I.H.R., Bangalore.

Parasitoids can be stored in their developmental stages (SHREAD, & GARMAN, 1934; EISLER & PLESS, 1972: ARCHER *et al.*, 1973) or as adults (ESMAILI & WILDE, 1972; ARCHER & EIKENBARY, 1973; JAYANTH & NAGARKATTI, 1985; JACKSON, 1986). In the present study, investigations were taken up to study the effect of cold storage on the emergence of *L. dactylopii* from mummies and survival of adults during storage.

MATERIALS AND METHODS

Culture of *L. dactylopii* was maintained on *P. citri* at room temperature ranging from 24° to 27°C (KRISHNAMOORTHY & SINGH, 1987). The first experiment was conducted with 2 to 3 day old mummies of *L. dactylopii*. They were grouped into batches of 10 each and held inside the glass vials of 7.5 × 2.5 cm and closed with cotton plug. The inner sides of the glass vials were smeared with lines of honey streak which served as source of food for emerging adults. The mummies held in vials

were later placed inside B.O.D. incubators which were preset with 5°, 10°, and 15° ± 0.5°C with 70–80% RH. Mummies from each temperature were taken out on 5th, 10th, 15th, 20th, 30th, 35th and 40th day of storage and held at normal room temperature of 24° to 27°C and 60–70% RH. Observations were recorded on percent emergence, time of emergence and longevity of emerged adults. Each storage period was replicated thrice.

In the second experiment, a similar study was conducted with newly emerged mated adults. Adults were provided with sufficient food during storage. Adult survival at each storage period and the longevity of stored fed adults at room temperature were recorded.

Moribund adults were considered as dead. The storage was terminated when there was no emergence or no survival of adults in two consecutive treatments. Zero values of mortality were converted into 0.01 and the data were transformed into corresponding angles (Arc. sine $\sqrt{\text{percentage}}$). An 'F' test was used to analyse the difference between the treatments. Correlations were worked out to find out the relation between the period of storage and the longevity of adults.

RESULTS AND DISCUSSION

There was no emergence of *L. dactylopii* from mummies stored at 5° and 10°C even when stored for 5 days (Table 1). Emergence of adult was not significantly affected when mummies were stored at 15°C for a period of 10 days. The emergence was found reduced gradually thereafter with increase in storage period but not significant. HANNA

TABLE 1. Effect of storage of mummies of *Leptomastix dactylopii* on the emergence of adults.

Period of storage (days)	$\bar{x}$ emergence of adult (%)* at		
	5°C	10°C	15°C
5	0.0	0.0	86.67 (72.27)
10	0.0	0.0	76.67 (61.90)
15	0.0	0.0	70.00 (57.68)
20	0.0	0.0	63.33 (52.75)
25	0.0	0.0	56.67 (48.83)
30	0.0	0.0	46.67 (43.06)
35	0.0	0.0	20.00 (26.06)
40	0.0	0.0	0.0
SEM	4.909	CD (P=0.05) =	14.717

*Mean of 3 replications.
Figures in parentheses are transformed values.

(1935) and EISLER & PLESS (1972) have also similarly reported that longer period of storage resulted in high mortality with other species of parasitoids. No emergence was recorded after 40 days of storage. These observations indicated that mummies were not hardy enough to protect the developmental stage of *L. dactylopii* from cold temperature unlike mummies of *Lysiphlebus testaceipes* (Cresson) which withstood even 1.7°C, according to ARCHER *et al.* (1973). Cocoons of *Allorhogas pyralophagus* Marsh were also found to be susceptible to cold temperature and could not be stored for more than 4 days at 5°C (ANONYMOUS, 1986). Thus mummies could be stored only at 15°C and 70 to 80% RH for any stop-gap arrangement and that too for a shorter period.

Data on the time taken for *L. dactylopii* to emerge from mummies held at room temperature after storage are presented in Table 2. Adults from the different treatments emerged only when the stored mummies were taken out and held at room temperature. Normally adults emerge in 7–9 days at room temperature of 24°–27°C and 60–70% RH. The time thus taken by *L. dactylopii* for emergence reduced significantly with the increase in storage period. ARCHER *et al.* (1973) also reported delayed emergence from mummies of *L. testaceipis* for more than 30 days. At each treatment taking into account the storage period plus pre-emergence period it is clear that the developmental time can be extended by 2–5 times. The delayed emergence from stored mummies may prove useful in planning timely releases and shipments to far off places. The longevity of the adults at room temperature, emerged from mummies stored at 15°C, is also furnished in Table 2. The adults did not survive as many days as normal adult survived (18.2 days) and the longevity of adults, though gradually reduced, it was not significant up to 20 days of storage.

The effect of cold temperature regimes on the survival of adult when sorted is furnished in Table 3. A very high mortality was observed in both 5° and 10°C indicating that

TABLE 2. Influence of temperature (15°C) on the emergence and longevity of *Leptomastix dactylopii* when stored mummies are held at room temperature of 24°–27°C and RH of 60–70%.

Period of storage (days)	Days taken to emerge	Longevity of adult (days)		
		Male	Female	Mean
5	6.86	13.63	13.13	13.38
10	5.21	10.80	11.13	10.97
15	4.50	10.56	11.36	10.96
20	4.67	12.67	9.67	11.17
25	4.00	5.80	5.44	5.62
30	2.44	2.89	6.00	4.45
35	1.80	1.20	3.70	2.45
40	0.0	0.0	0.0	0.0
r — 0.7124		SEM : 0.90226		
		CD (P = 0.05) = 2.9420		

TABLE 3. Effect of storage of the adults of *Leptomastix dactylopii at* at low temperatures.

Period of storage	$\bar{x}$ mortality of adult (%)								
	Male			Female			Pooled data		
	5°C	10°C	15°C	5°C	10°C	15°C	5°C	10°C	15°C
5	90.0 (74.98)	73.33 (63.83)	0.0 (0.06)	93.33 (77.69)	86.67 (72.27)	0.0 (0.06)	91.67 (73.37)	63.33 (52.84)	0.0 (0.06)
10	100 (90.0)	76.67 (61.90)	0.0 (0.06)	100 (90.00)	93.33 (77.69)	0.0 (0.6)	100 (90.0)	85.0 (67.38)	0.0 (0.06)
15	100 (90.0)	100 (90.0)	13.33 (21.14)	100 (90.0)	100 (90.0)	6.67 (12.29)	100 (90.0)	100 (90.0)	10 (18.43)
20	—	100 (90.0)	33.33 (35.20)	—	100 (90.0)	53.33 (46.99)	—	100 (90.0)	43.33 (41.11)
25	—	—	86.67 (68.83)	—	—	86.67 (68.83)	—	—	86.67 (68.83)
30	—	—	100 (90.0)	—	—	100 (90.0)	—	—	100 (90.0)
35	—	—	100 (90.0)	—	—	100 (90.0)	—	—	100 (90.0)
SEM:	2.97	5.45	1.63	2.33	4.08	3.20	0.69	1.73	1.67
CD($P=0.05$) :	9.01	16.52	4.96	7.05	12.37	9.70	2.11	5.25	5.05

Figures in parentheses are transformed values.

5° and 10°C were not at all ideal for storing adults. At 15°C, no mortality was observed up to 10 days of storage but mortality increased significantly with increase in duration of storage. Similar inverse relationship was also observed by ARCHER *et al.* (1973) and JAYANTH & NAGARKATTI (1985) with other species of natural enemies. Females were more susceptible than males at all test temperatures. The males were more susceptible in the case of *Bracon brevicornis* Wesmael (JAYANTH & NAGARKATTI, 1985). The longevity of surviving stored adults at room temperature is furnished in Table 4. The adults had survived for shorter period than the adults emerged from stored mummies (Table 2). The correlation and regression analysis revealed that the longevity decreased with increasing period of storage and increased with increasing temperature both in the case of male and female. Thus the predicted equation is:

Male : $L = 0.91 - 0.1540\ D + 0.2734T$

Female: $L = 1.06 - 0.1841\ D + 0.3354T$

L = Longevity; D = Days; T = Temperature

In the present study acclimatization of mummies and adults was not pursued as the temperature levels for storage study were high compared to ARCHER *et al.* (1973). ARCHER & EIKENBARY (1973) and JAYANTH & NAGARKATTI (1985) have also not used the acclimatization procedure although they conducted the storage study at 1.7° to 4.6°C and 5°C respectively. Despite very high

TABLE 4. Longevity of the adults of *Leptomastix dactylopii* at room temperature after storage at low temperatures.

Period of storage (days)	$\bar{x}$ longevity (days) at room temperature of 24 to 27°C					
	Male			Female		
	5°C	10°C	15°C	5°C	10°C	15°C
5	1.0	3.1	5.87	1.3	3.5	6.40
10	—	1.3	3.67	—	1.9	5.53
15	—	—	3.80	—	—	4.60
20	—	—	0.87	—	—	0.87
25	—	—	0.47	—	—	0.67
30	—	—	—	—	—	—
35	—	—	—	—	—	—
r =	−0.6040			−0.6004		

relative humidity provided (KAJITHA, 1967), *L. dactylopii* did not survive at low temperature. The present findings thus substantiate the report of LONGO & BENFATTO (1982) that *L. dactylopii* could not survive in winter in Sicily or Main land Italy and suggested releases of the parasitoid after every winter. Thus *L. dactylopii* could be stored to certain extent as mummies at 15°C and 70–80% RH as a stop-gap arrangement for large scale release.

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ECOLOGICAL STUDIES ON CITRUS PSYLLA, *DIAPHORINA CITRI* KUWAYAMA (HEMIPTERA: PSYLLIDAE) WITH SPECIAL REFERENCE TO ITS SPATIAL DISTRIBUTION AND SAMPLING PLAN

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Basic ecological studies on spatial distribution and sampling plan were conducted to understand the population dynamics of the citrus psylla, *Diaphorina citri* Kuwayama. New shoots of citrus were sampled. The eggs and nymphs followed contagious distribution, whereas the adult distribution was random to aggregated. The data fitted a negative binomial model, with a probability range of 0.03 to 0.99, and 0.19 to 0.98 for eggs and nymphs, respectively. There was no significant differences in the mean population density among the four directions. Sample sizes recommended for *D. citri* are 40, 38, and 19 shoots/tree for eggs, nymphs and adults respectively. The relevance of these findings to the management of *D. citri* is discussed.

(*Key words*: citrus, psylla, *Diaphorina citri*, spatial distribution, sampling)

INTRODUCTION

The citrus psylla, *Diaphorina citri* Kuwayama is one of the key pests of citrus in India. It attacks almost all the commercially cultivated citrus species. Apart from the feeding damage, it acts as a vector of greening disease of citrus which is the prime cause of citrus decline in India (BINDRA, 1966, 1969; BHUTANI, 1979; CAPOOR et al., 1967). Besides India, it is widely distributed throughout tropical and sub-tropical Asia and the Far East and has been recorded from Pakistan, Sri Lanka, Burma, Malaysia, Indonesia, Southern China, Macao, Taiwan and the Philippines (BINDRA, 1970).

The present basic ecological studies on spatial distribution, and sampling plan were conducted to understand the population dynamics of *D. citri* for its effective management.

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MATERIALS AND METHODS

The present studies were conducted at the Experimental Research Station of the Indian Institute of Horticultural Research, Hessaraghatta, Bangalore on ten trees of acid lime selected at random, having uniform size and age. These trees were kept free of insecticidal sprays during the study (July-August 1989). From each tree ten new shoots (4 to 5 cm) were sampled at random from each cardinal direction viz., East, West, North and South making a total sample of 40 shoots per tree. The shoots were cut and collected in glass tubes and brought to laboratory for population estimation. The egg and nymph populations were counted by observing the shoots under a binocular dissection microscope. However, adult population was counted in the field.

The data were subjected to the analysis of dispersion indices, variance-mean ratio, mean crowding, LLOYDS (1967) index of

patchiness, Iwao's patchiness regression (IWAO, 1968) and the exponent-k. After finding the distribution trend from dispersion indices, the data were fitted to a negative binomial distribution for within tree and overall population. The fit to the negative binomial was tested against chi-square and the probability of fit was computed in all cases. The mean clump size (λ) was calculated to identify the cause of aggregation from the following formula of ARBOUS & KERRICH'S (1951).

$$\lambda = \frac{\bar{x}}{2k} V$$

where $\bar{x}$ = mean, and v = a function with a χ^2 fdistribution with 2k degrees of freedom at the 0.5 probability level.

Analysis of variance (ANOVA) was calculated for the data on population from four directions of a tree to find if the mean population density of *D. citri* differed significantly within the sections of the canopy. The correlations of the pest population in these sections with the total population in the tree were also worked out.

To calculate the optimum sample number/tree for field estimation of psylla population the formula of COCHRAN (1977) was used, with margins of errors at 10% and 20% (d) with reference to mean values at 5% confidential limits (*t*–value).

RESULTS AND DISCUSSION

Spatial distribution of eggs:

The different parameters, mean density ($\bar{x}$), variance (S^2), variance mean ratio ($S^2/\bar{x}$), index of mean crowding (x*), Lloyds index of patchiness, ($x^*/\bar{x}$), Iwao's patchiness regression, exponent k, the chi-square values with degrees of freedom, the probability of fit, and mean clump size (λ) representing the within tree and overall distribution pattern of *D. citri* are presented in Table 1.

TABLE 1. Spatial distribution of citrus psylla eggs on acid lime.

Tree No.	Mean $\bar{x}$	Variance S^2	Variance/ ($S^2/\bar{x}$) Mean ratio	Exponent 'k'	Mean crowding (x*)	Lloyd's index of patchiness	Negative binomial		Probability of fit for negative binomial	Mean Clump size (λ)
							χ^2	df		
1.	4.10	52.09	12.70	0.35	15.80	3.85	2.14	4	0.71	2.69
2.	7.60	65.42	8.60	0.99	15.20	2.00	2.38	5	0.79	5.25
3.	7.20	115.34	16.01	0.47	22.21	3.08	0.096	4	0.99	3.52
4.	5.22	74.48	14.25	0.39	18.48	3.53	11.01	4	0.03	3.07
5.	2.17	17.48	8.20	0.30	9.37	4.31	2.20	3	0.53	1.66
6.	1.75	6.91	3.94	0.59	4.69	2.68	5.14	3	0.17	0.92
7.	2.87	63.85	22.21	0.13	24.08	8.37	0.57	2	0.75	5.08
8.	0.75	3.78	5.04	0.18	4.79	6.39	0.245	1	0.64	0.96
9.	1.92	41.66	21.64	0.93	22.56	11.72	0.51	1	0.49	1.30
10.	1.75	8.65	4.94	0.44	5.69	3.25	1.68	3	0.64	0.91
Pooled	3.02	43.94	14.54	0.22	16.56	5.48	9.63	17	0.92	3.15

Iwao's Patchiness Equation = $x^* = 8.93 + 1.62\ \bar{x}$.

The data presented in Table 1 revealed that variance exceeded the mean in all the sets, indicating a contagious or aggregated distribution of eggs.

The mean crowding values exceeded the mean density, and thereby LLOYD's (1967) index of patchiness became greater than unity in all cases, which confirmed the aggregation pattern. The trend was further reflected by the exponent k with values ranging from 0.13 to 0.99 in the different sets of data.

To understand the distribution further, IWAO's (1968) patchiness regression was fitted based on the linear relationship between mean crowding and mean density, over a range of different densities. $x^* = (\alpha + \beta\bar{x})$ which worked out to $x^* = 8.93 + 1.62\bar{x}$. The value of the index of basic contagion ($\alpha = 8.93$) being greater than 0 indicated a positive association between individuals in a colony and (β) the coefficient of density contagiousness being greater than one confirmed the aggregation among colonies.

The causes of aggregation for the population described by the negative binomial distribution were explained by mean clump size (λ). Among the sets, the clump size was varying (both below and above two). The average of 3.15, however, reflected the role of both environment and oviposition behaviour in the aggregation pattern of eggs.

The results of the analysis of variance of the mean population density (Table 2) revealed that the four directions did not significantly affect population density. The populations in the four directions were correlated with the total population (Table 2). Those of the three directions (West, North and South) were highly correlated (at 1%) whereas east was significant at 5% level. Thus any direction could be sampled from the point of view of accuracy and feasibility.

Spatial distribution of nymphs:

The variance was greater than the mean, which indicated an aggregated distribution.

TABLE 2. Analysis of variance and correlation of section and total tree population.

Directions	Average egg	Correlation with total ('r')	Average nymph	Correlation with total ('r')	Average adult	Correlation with total ('r')
East	3.15	0.65*	4.80	0.94**	0.34	0.88**
	(0.96)		(1.27)		(–0.44)	
West	2.60	0.92**	2.35	0.53	0.20	0.50
	(0.74)		(0.79)		(–0.46)	
North	3.62	0.87**	2.59	0.91**	0.10	0.09
	(1.04)		(0.86)		(–0.52)	
South	2.70	0.80**	4.06	0.91**	0.03	–0.12
	(0.67)		(1.23)		(–0.63)	
	N.S.		N.S.		N.S.	

N.S. — Not significant.
* — Significant at 5%.
** — Significant at 1%.

The index of mean crowding exceeded the mean density and therefore, LLOYD's (1967) index of patchiness was greater than unity in all the sets showing that the nymph population followed a contagious distribution. This was further confirmed by the 'k' values. The IWAO's (1968) patchiness regression equation was calculated ($x^* = 1.43 + 2.46\bar{x}$) by which also the aggregated distribution was confirmed (Tables 3 and 4). In 60% of the cases the clump size was less than 2, probably influenced by the limited supply of young shoots on which the nymphs congregate and feed.

Statistically significant differences were not observed in the mean population densities among the four directions, based on analysis of variance. The population from East, North and South were highly correlated with total population. However, West showed no correlation (Table 2).

Spatial distribution of adults:

In the adult population of psylla, 30% of the trees showed a tendency to aggregation, and the remaining showed random distribution with variance-mean ratio almost equal to one (Table 5). The Lloyd's index of patchiness did not show consistency in this case, hence variance mean ratio and 'k' values were used to explain the distribution. Overall pooled distribution, however conformed to aggregation. Further, the adult population did not show any significant correlation with total from any direction (Table 2).

Sample sizes:

The optimum number of shoots required for a reasonably accurate estimation of the egg population at 10% and 20% margins of error (d) with reference to the mean at 5% value of the confidence limits (t–value) were 40 and 39 per tree (Table 4). A sample of

TABLE 3. Spatial distribution of citrus psylla nymphs on acid lime.

Tree No.	Mean ($\bar{x}$)	Variance (S^2)	Variance/Mean ratio ($S^2/\bar{x}$)	Exponent 'k'	Mean crowding (x^*)	Lloyd's index of Patchiness	Negative binomial χ^2	Negative binomial df	Probability of fit for negative binomial	Mean clump size (λ)
1.	10.80	176.52	16.34	0.70	26.14	2.42	9.40	5	0.19	6.40
2.	6.45	67.68	10.49	0.67	15.94	2.47	7.04	5	0.22	3.71
3.	4.15	71.82	17.30	0.25	20.45	4.92	9.11	3	0.30	3.81
4.	4.30	39.95	9.29	0.51	12.59	2.92	4.06	4	0.40	1.98
5.	1.47	5.02	3.40	0.61	3.88	2.63	1.26	3	0.74	0.79
6.	5.50	51.89	9.43	0.65	13.93	2.53	4.30	5	0.51	3.13
7.	1.35	6.07	4.50	0.38	4.85	3.59	0.15	3	0.98	0.82
8.	2.17	14.19	6.52	0.39	7.70	3.54	0.66	3	0.88	1.27
9.	1.65	4.95	3.00	0.82	3.65	2.21	0.52	3	0.91	1.05
10.	0.45	1.17	2.61	0.27	2.06	4.58	0.02	1	0.88	0.36
Pooled	3.44	45.23	13.14	0.28	15.58	4.52	35.89	18	<0.01	2.82

Iwao's Patchiness equation $x^* = 1.43 + 24.6\,\bar{x}$.

TABLE 4. Optimum sample number/tree for field estimation of psylla population.

Sl. no.	5% *t* value					
	Egg		Nymph		Adult	
	Permissible margins of error		Permissible margins of error		Permissible margins of error	
	10%	20%	10%	20%	10%	20%
1.	39.92	39.68	39.97	39.90	18.58	7.14
2.	39.93	39.74	39.93	39.75	7.14	2.05
3.	39.96	39.85	39.94	39.77	34.82	25.08
4.	39.94	39.77	39.89	39.58	11.13	3.59
5.	39.76	39.07	39.19	36.95	6.37	1.80
6.	39.40	37.71	39.91	39.68	39.52	38.15
7.	39.93	39.74	39.32	37.44	38.01	33.09
8.	38.92	36.03	39.70	38.85	19.22	7.49
9.	39.90	39.60	39.17	36.89	35.89	27.42
10.	39.52	38.16	36.72	29.47	7.14	2.05
Mean	39.71	38.93	39.37	37.82	19.21	14.78
Rounded off	40.00	39.00	39.00	38.00	19.00	15.00

TABLE 5. Spatial distribution of citrus psylla adults on acid lime.

Tree no.	Mean ($\bar{x}$)	Variance (S^2)	Variance mean ratio ($S^2/\bar{x}$)	Exponent 'k'	Mean crowding (x^*)	Lloyd's Index of Patchiness
1	0.1	0.090	0.92	—	0.02	0.23
2	0.025	0.025	1.00	—	0.025	0.99
3	0.07	0.07	0.94	—	0.02	0.31
4	0.05	0.04	0.97	—	0.02	0.48
5	0.02	0.02	1.00	—	0.02	0.99
6	0.90	8.60	9.56	0.10	9.46	10.51
7	0.52	1.99	3.80	0.18	3.33	6.34
8	0.05	0.10	2.00	0.05	1.05	21.00
9	0.10	0.09	0.92	—	0.02	0.23
10	0.02	0.02	1.00	—	0.02	0.99
Pooled	0.17	1.05	6.20	0.32	5.37	31.52

Iwao's Patchiness Equation $x^* = -0.38 + 9.87\ \bar{x}$.

40 shoots/tree at 10% margin of error and at 5% *t* value is reasonably good for survey and control studies (SOUTHWOOD, 1978).

Among the samples of 39 and 38 shoots/tree at 10% and 20% margins of error at 5% *t*–value, 38 shoos/tree at 20% margin of error at 5% *t*–value (Table 4) is applicable for population estimation studies.

In the case of adults a sample of 19 shoots/tree at 10% margin of error at 5% *t*–value (Table 4) can be taken as tne optimum sample size.

The present study on the spatial distribution of *D. citri* revealed that eggs and nymphs followed contagious distribution which also reported by WANG (1981) in the case of *D. citri* in Taiwan. The distribution of adults did not show definite pattern. However from pest management point of view, the eggs and nymphal stages matter most, because immediately after hatching, the nymphs start sucking the sap from the plant. So any control strategy needs to be directed at early stages. Egg sampling, therefore, is crucial to fix a time of spray. The trend of the pest to change from an early aggregated distribution to random distribution in adults indicates the role of key mortality factors operating. This, therefore, opens new vistas in the study of *D. citri* for which the sampling plan outlined here will be applicable.

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INSECTS ASSOCIATED WITH SOME FOREST TREES IN TWO TYPES OF NATURAL FORESTS IN THE WESTERN GHATS, KERALA (INDIA)

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Insects associated with 38 species of forest trees in the Western Ghats were studied and a total of 92 species of insects were collected and identified. Majority of them were phytophagous, mostly belonging to the Orders Lepidoptera and Coleoptera. The study indicated that there was no major damage due to pest incidence except for occasional mild defoliation of *Grewia tiliaefolia*, *Haldina cordifolia*, *Lannea coromandelica*, *Tectona grandis*, *Anacolosa densiflora*, *Actinodaphne madraspatana*, *Cinnamomum verum* and *Litsea floribunda* due to foliage feeders. The study also indicated that of the various insects recorded, about 65% are new records for the respective hosts in India.

(*Key words*: insect pests, forest trees, Western Ghats, Kerala)

INTRODUCTION

With increasing demand for wood, forest plantations of a variety of tree species are being tried at several places in Kerala. Forest plantations of most tree species often suffer heavy damage due to insect pests while pest outbreaks seldom take a serious turn in natural forests.

Information on the insects associated with the various forest trees under natural conditions will be useful in predicting the potential insect pests of various tree species and will be useful in future plantation trials. This paper forms part of a research programme undertaken to study the pest incidence in natural forests (MOHANADAS et al., 1988).

MATERIALS AND METHODS

This study was carried out in 4 study areas of approximately 1 sq. km two each for the moist deciduous and evergreen forest types. Plots representing the moist deciduous forest type were located in Trichur Forest Division, one site in the Peechi Forest Range adjacent to the catchment area of Peechi dam and the other in the Wadakkancherry Forest Range, in the catchment area of Vazhani dam. The two sites were separated by a distance of about 25 km. Similarly, the plots representing the evergreen forest type were selected in the Chalakudy Forest Division, in the catchment area of the Sholayar dam, the two plots being separated by a distance of about 20 km.

Based on a preliminary enumeration of the tree flora, 20 species in the moist deciduous forest and 18 species in the evergreen forest were selected for study. For a given forest type, 5 replicates of each species were selected which were distributed between the 2 plots, 2 in one plot and the remaining in the other, due to the difficulties in finding adequate number of trees of some of the included species in one plot alone. All the areas were visited once, in every month for a period of 21 months from September 1983 to May 1985 so as to cover two growth seasons.

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The insects recorded in this study are listed under their respective host plants with brief notes on their habits and occurrence. For information on the insects recorded previously on the various trees studied here, reference was made to BEESON (1941), BHASIN & ROONWAL (1954), BHASIN et al. (1958), BROWNE (1968), MATHEW (1986) as well as MATHUR & SINGH (1954–1961).

RESULTS AND DISCUSSION

All the tree species under observation in both the forest types showed some damage caused by insects. The most common type of damage was leaf feeding noticed on all tree species some time or other. Occurrence of a few live tree borers (*Xystrocera globosa* on *Albizia odoratissima* and *Chrysochroa* sp. on *Mesua nagassarium*) was found to be important since they caused mortality of trees in the natural stands. Other types of damage (gall forming and sap sucking) were rare and significant.

Altogether about 90 species of insects were recorded from the various trees studied here of which about 65 species could be identified (Tables 1 and 2). Maximum number of insect species (12) were recorded on *Garuga pinnata* followed by *Careya arborea* (10) and *Grewia tiliaefolia* (9). The species *Bridelia squamosa*, *Lagerstroemia microcarpa* and *Xylia xylocarpa* had 5–8 insect pests. All the remaining had 4 or less. The insects recorded here form only a small proportion of the insects recorded earlier (Fig. 1). It is also interesting to note that of the 65 species recorded here, 42 species, that is 65% are new records for their respective hosts in India.

Although the number of insects recorded on each of the tree species in the moist deciduous forests was fairly high it does not imply that these trees are more pest prone or that in the evergreen forests the insect activity is less. In fact we obtained a richer and more varied representation of insect fauna in samplings carried out during the study. Probably the specialities in the composition of vegetation might be a factor that limits the occurrence of several species of insects colonising any particular tree species and more studies are required to get a better understanding of this aspect.

This study has also shown that although a number of insect pests are associated with each of the tree species no major build up by

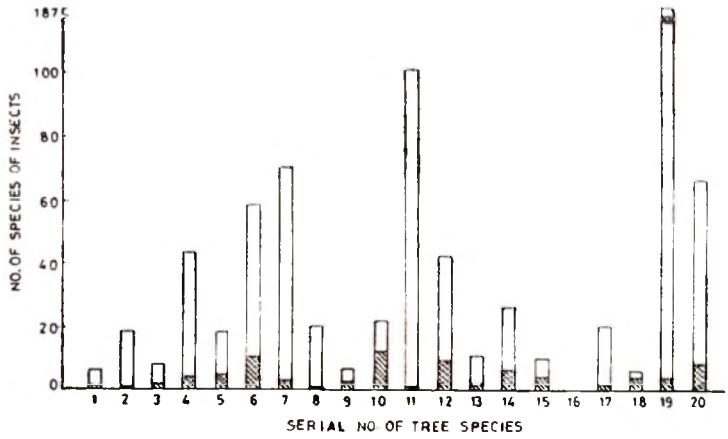

Fig. 1. Number of insect species recorded in this study (hatched area) and in the literature on 20 species of trees in the moist deciduous forest.

TABLE 1. Insects associated with trees studied in the moist deciduous forest.

	Tree	Insects recorded	Remarks
		Lepidoptera	
1.	*Albizia lebbeck*	Unidentified geometrid caterpillar	Foliage feeder. Minor pest.
2.	*A. odoratissima*	None	Trees showed minor damage to foliage due to insect feeding. The cerambycid *Xystrocera globosa* was found to affect the injured trees outside the experimental plot.
		Lepidoptera	
3.	*Alstonia scholaris*	*Parotis vertumnalis* (Guenee) (Pyraustidae)	Potential defoliator often causing heavy defoliation of *A. scholaris* (Mathew, 1981).
		Unidentified Psyllidae	
4.	*Bombax* sp.	Lepidoptera	
		Thalassodes opalina Butler (Geometridae)	Leaf feeder. Minor pest.
		Euproctis fraterna (Moore) (Lymnatridae)	Leaf feeder. Minor pest.
		Coleoptera	
		[1]*Indomias hispidus* (Marshall) (Curculionidae)	Caused minor defoliation of trees. *I. cretaceaus* is already reported to be a pest of this tree in S. India (Browne, 1968).
		Glenea homonospila Thoms. (Cerambycidae)	Borer in the stem of standing trees. Minor pest.
5.	*Bridelia squamosa*	Lepidoptera	
		Unidentified geometrid	All the lepidopteran caterpillars were found to affect the fresh foliage. Not found to cause any major damage.
		Unidentified pyralid	
		Unidentified Pterophorid	
		Unidentified leaf miner	
		Coleoptera	The females of *A. scitulus* cut and rolled the edges of leaves for oviposition. Adults fed on the foliage but the damage was minor.
		[1]*Apoderus scitulus*. Wlk. (Curculionidae)	

[1]Species recorded for the first time in India on the given host. (contd.)

	Tree	Insects recorded	Remarks
6.	*Careya arborea*	Lepidoptera	
		[1]*Aeolonthes dicraea* (Meyrick) (Oecophoridae)	Among these, noticeable damage was caused only by the unidentified pyralid which webbed the tender leaves and shoots together and fed from within.
		[1]*Limnoecia* sp. nr. *peronodus* Meyr. (Cosmopterygidae)	
		Unidentified pyralid	
		Unidentified geometrid	
		Unidentified leaf miner	
		Homoptera	
		[1]*Tettigoniella indistincta* Wlk. (Jassidae)	Sap sucking.
		[1]*Centrotypus* sp. (Membracidae) Coleoptera	Sap sucking.
		[1]*Teluropus ballardi* Marshall (Curculionidae)	Borer in the fruit.
		Diptera	
		[1]*Dacus* (*Bactrocera*) sp. nr. *tuberculatus* (Bezzi) (Tephritidae)	Borer in the fruit.
7.	*Cassia fistula*	Lepidoptera	
		Catopsila pyranthe Herbst. (Pieridae)	Occasionally causing total defoliation of trees. Potential pest.
		Deba surrectalis Wlk. (Pyralidae)	Feeds inside webbed leaves.
		Coleoptera	
		[1]*Maladera* sp. (Scarabaeidae: Melolonthinae)	Feeding along the leaf margin.
8.	*Dalbergia latifolia*	Coleoptera	
		[1]*Peltotrachelus cognatus* Marshall. (Curculionidae)	Feeds on foliage. Minor pest.
9.	*Dillenia pentagyna*	Lepidoptera	
		Unidentified pyralid	Feeds on tender foliage.
		Unidentified noctuid	Feeds on tender foliage.
		Homoptera	
		[1]*Phymatostetha deschamps* Lin. (Cercopidae)	A known pest of plantain. Probably sucking sap from tender foliage.
10.	*Garuga pinnata*	Lepidoptera	
		Macalla nubilalis Hamp. (Phycitidae)	Feeds on foliage.

(contd.)

	Tree	Insects recorded	Remarks
		[1]*Assara albicostalis* Wlk. (Phycitidae)	Feeds on foliage.
		[1]*Earias flavida sulphuraria* Moore. (Noctuidae)	Feeds on foliage.
		[1]*Adoxophyes moderanata* Wlk. (Tortricidae)	Feeds on foliage.
		Unidentified leaf miner Coleoptera	Feeds on foliage.
		[1]*Adoretes coronatus* Burm. (Scarabaeidae)	Feeds on foliage.
		[1]*Apophylea sericea* Fb. (Chrysomelidae)	Feeds on foliage
		[1]*Ophrida marmoria* Wield. (Chrysomelidae)	Feeds on foliage.
		[1]*Campsosternus* sp. (Elateridae)	Feeds on foliage.
		Homoptera [1]*Drabescus* sp. (Cicadallidae)	Sap sucking.
		[1]*Coptosoma variegata* (H.S.) (Plataspididae)	Sap sucking.
		Phacopteron lentiginosum Buckton (Psyllidae)	Gall forming.
11.	*Gmelina arborea*	Lepidoptera *Diacrotricha leucomochla* Fletcher (Pterophoridae)	Feeds along the sides of the principal veins of leaves.
12.	*Grewia tiliaefolia*	Lepidoptera	Leaf webber.
		Lygropia orbinusalis Wlk. (Pyraustidae) Unidentified Geometridae Unidentified Arctiidae Coleoptera Curculionidae *Nisathra medurensis* Jac. *Henicolabus octomaculatus* Tek. *Indomias hispidus* (Marshall) *Baris* sp. *Apion* sp.	Of the beetles, *H. octomaculatus* caused most damage by riddling the leaves with holes mostly during the months May to September.

(contd.)

	Tree	Insects recorded	Remarks
13.	*Haldina cordifolia*	Unidentified pyralid	Feeds within folded leaves.
		Unidentified beetle	Feeding by the beetle characteristically caused several holes on the leaf resulting in the loss of more than 50% of the foliage of some trees during the months June to October.
14.	*Lagerstroemia microcarpa*	Lepidoptera	
		[1]*Striglina scitaria* Wlk. (Thyrididae)	Caterpillars webbed the leaves and fed from within.
		Coleoptera	
		[1]*Apocrypta* sp. (Chrysomelidae)	
		[1]*Leiochrinus nilgirianus* Kaszab. (Tenebrionidae)	
		Myllocerus gracilis Marshall (Curculionidae)	Both species of *Myllocerus* fed along the leaf margin causing several holes.
		Myllocerus sp. (Curculionidae)	
		Notomulciber? *decemmaculatus* Breuning (Cerambycidae)	The beetle *A. bicaudatus* caused extensive damage by feeding irregularly along the leaf margin.
		Adoretus bicaudatus Arrow (Scarabaeidae)	
15.	*Lannea coromandelica*	Lepidoptera	*E. reicheana* fed on the green matter of the leaves giving it a dry and withered appearance. Over 50% leaf loss was observed on some occasions. All the other species caused only negligible damage.
		Unidetified caterpillar	
		Coleoptera	
		[1]*Epistictina reicheana* (Guerin-Meneville) (Chrysomelidae)	
		[1]*Philopona inornata* (Jacoby) (Chrysomelidae)	
		Homoptera	
		Unidentified Cicadellidae	
16.	*Piliostigma malabaricum*	Lepidoptera	
		[1]*Parotis vertumnalis* (Guen.) (Pyraustidae)	Leaf webber.
		Homoptera	
		[1]Unidentified Psyllidae	The psyllid occurred gregariously on small branches and were attended by ants.
17.	*Terminalia bellirica*	Lepidoptera	
		[1]*Lamida moncusalis* Wlk. (Pyralidae)	*L. moncusalis* is known as a pest of mango and cashew. It was found to web the leaves and shoots together and feed from within.

(contd).

	Tree	Insects recorded	Remarks
		Coleoptera [1]*Dystropicus* sp. (Curculionidae)	
18.	*T. crenulata*	Lepidoptera [1]Unidentified leaf miner Coleoptera [1]*Ergania*? *baudii* Faust. (Curculionidae) Homoptera [1]*Poophilus* sp. (Cercopidae) [1]*Gargara* sp. (Membracidae)	
19.	*Tectona grandis*	Lepidoptera *Hyblaea puera* Cramer (Hyblaeidae) *Eutectona machaeralis* (Wlk.) (Pyraustidae) Hemiptera [1]*Ricania speculum* (Wlk.) Diptera *Asphondylia tectonae* Mani (Cecidomyidae)	*H. puera*, the well known teak defoliator caused more than 50% leaf loss of some trees in June 1983. At other times, leaf loss by this insect never exceeded 5%. Gall formation by *A. tectonae* was prevalent on some trees.
20.	*Xylia xylocarpa*	Lepidoptera [1]*Maruca testulalis* Geyer [1]*Phycita* sp. nr. *obliquifaciella* *Phycita* sp. *Xyroptila tectonica* Meyr. (Pterophoridae) *Arbela tetraonis* Moore (Melarbelidae) Coleoptera Curculionidae [1]*Apoderus scitulus* Wlk. [1]*A. gracilis* Voss. [1]*Eugnathus curvus* Faust. *Chrysomelidae* [1]*Hoplasoma unicolor* (Illiger)	Leaf webber, occasionally causing moderate damage. Caterpillars bore into the terminal shoots of seedlings. Feeds on foliage. Feeds on bark of trees. All the beetles were found on tender leaves. Feeding by *A. scitulus* was characterised by small holes with brown periphery.

TABLE 2. Insects associated with trees studied in the evergreen forest.

Tree species	Damage noticed	Insects recorded in this study and notes on damage
1. *Actinodaphne madrasapatana*	Leaf feeding	None.
2. *Anacolosa densiflora*	Leaf feeding	Undetermined chrysomelid (leaf feeding).
3. *Antidesma bunius*	Leaf feeding	None.
4. *Calophyllum polyanthum*	Leaf feeding	None.
5. *Cinnamomum verum*	Leaf feeding	Undetermined lepidopteran (leaf rolling). Undetermined bagworm, resembling *Pteroma plagiophleps* Mampson (leaf feeding).
6. *Cullenia exarillata*	Leaf feeding	None.
7. *Dysoxylum malabaricum*	Leaf feeding	None.
8. *Holigarna arnottiana*	Leaf feeding	None.
9. *Knema attenuata*	Leaf feeding	None.
10. *Litsea floribunda*	Leaf feeding	Undetermined lepidopteran (feeds along veins of leaves).
	Wood boring	Undetermined coleopteran (bores into heartwood, rare occurrence).
11. *Mesua nagassarium*	Wood boring	Undetermined buprestid borer. (tunnels into heartwood, sometimes causing death of tree: probably *Chrysochroa* sp.).
12. *Dimocarpus longan*	Leaf feeding	None.
13. *Olea dioica*	Leaf feeding	None.
14. *Palaquium ellipticum*	Leaf feeding	[1]*Striglina scitaria* Wlk. (Lepidoptera, Thyrididae) (a polyphagous leaf webbing caterpillar).
15. *Syzigium cumini*	Leaf feeding	None.
16. *Toona ciliata*	Leaf feeding	None.
17. *Vateria indica*	Leaf feeding	[1]*Rhodoneura* sp. nr. *myrtaceae* Drury (Lepidoptera, Thyrididae).
18. *Vepris bilocularis*	Leaf feeding	None.

[1]Species recorded for the first time in India on the given host.

any one insect species was observed. This could be due to the various natural control factors that are operating in the undisturbed forest ecosystem. However NAIR & SUDHEENDRAKUMAR (1986) have reported that regular outbreaks of *Hyblaea puera* do occur in natural stands of teak during the flushing season but do not become conspicuous due to the smaller population size and/or the scattered occurrence of the trees. Probably continued observations are necessary for arriving at a satisfactory conclusion on the pest incidence patterns in the natural forests and the present study is only a preliminary one in this regard.

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NATURAL ENEMIES OF THE BAGWORM, *PTEROMA PLAGIOPHLEPS* HAMPSON (LEPIDOPTERA : PSYCHIDAE) IN KERALA (INDIA)

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Pteroma plagiophleps **Hampson is a major defoliator of several tree species in Kerala, India. The occurrence of the various natural enemies of this insect as well as its impact on the pest population build up under the field conditions was studied. As much as 25 – 38% reduction in the pest population was recorded on some occasions mostly due to parasitism by *Goryphus* sp. and *Acropimpla* sp. nr. *leucotoma* (Cameron) (Ichneumonidae) as well as by *Brachymeria* sp. nr. *plutellae* Joseph, Narendran and Joy (Chalcididae). Although 15 other species of parasitoids were collected from the field, they were present only in small numbers. Instances of mortality of early and late instar larvae and pupae due to unidentified pathogenic organisms were also noticed.**

(*Key words*: *Pteroma plagiophleps*, bagworm, Psychidae, natural enemies, Kerala)

INTRODUCTION

Pteroma plagiophleps Hampson is an important defoliator of several tree species in Kerala including *Paraserianthes falcataria* (Linn.) Fosb, *Delonix regia* (Boj.) Rafin. etc. Its biology, economic importance and possible control have been discussed in detail by NAIR & MATHEW (1988).

The role of natural enemies in the management of bagworm population is well recognized. KULMAN (1965) reported 25% mortality in natural populations of the evergreen bagworm, *Thyridopteryx ephemeraeformis* (Haworth) due to various natural enemies. In the case of the South African wattle bagworm, *Acanthopsyche junodi* (Heylaerts), HARDENBERG (1919) reported 24% mortality due to various parasitoids and predators. SANKARAN (1970, 1972) reported several species of parasitic and predatory organisms affecting the bagworms associated with the oilpalms in Malaysia. However, very little is known about the natural enemy complex of *P. plagiophleps*.

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RESULTS AND DISCUSSION

In the present study, 18 species of parasitic insects belonging to five families of the Order Hymenoptera were collected and identified as listed in Table 1. They were mostly reared from the pupae of *P. plagiophleps* collected from *P. falcataria*. Some were from pupae collected on *D. regia* and *Terminalia catappa* (Linn.). The maximum number of parasitoids recorded belonged to the families, Ichneumonidae and Chalcididae. The signs of parasitism was evident from the neatly cut exit holes present on the bags. The parasitoid species involved could be established by relating the size of the parasitoid exit holes and the parasitoids collected.

The impact of parasitoids on the bagworm population was also studied in the samples of *P. plagiophleps* collected from various host plants. As much as 25 – 38% parasitism was recorded on some occasions (Table 2) showing that it is a significant mortality factor. Since only 3 parasitoids viz., *Goryphus* sp., *Acropimpla* sp. nr. *leucotoma* as well as *Brachymeria* sp. nr. *plutellae* were the most

TABLE 1. List of insect parasitoids of *Pteroma plagiophleps* collected on various host trees in Kerala.

Sl. no.	Parasite species of Hymenoptera	Place, date and host tree of the bagworm		
	FAMILY - CHALCIDIDAE			
1.	*Brachymeria wittei* (Schmitz.)	Vazhachal	July 1983	*Paraserianthes falcataria*
2.	*B. plutellae* Joseph, Narendren & Joy	Vazhachal	April 1983	*Delonix regia*
3.	*B. margaroniae* Joseph, Narendran & Joy	Vazhachal	—	*P. falcataraia*
4.	*Brachymeria* sp.	Puthukad	April, 1981	*D. regia*
	FAMILY - EULOPHIDAE			
5.	*Euplectrus* sp.	Vazhachal	Jan. 1981	*P. falcataria*
6.	*Tetrastichus* sp. (*miser* - group)	Vazhachal	Jan. 1981	*P. falcataria*
	FAMILY - EURYTOMIDAE			
7.	*Eurytoma* sp.	Vazhachal	Jun. 1980	*P. falcataria*
		Puthukad	Oct-Dec, 1979, 1980	*D. regia*
	FAMILY - ICHNEUMONIDAE			
8.	*Acropimpla* sp. nr. *leucotoma* (Cameron)	Vazhachal	Dec. 1978	*P. falcataria*
9.	*Chirotica* sp.	Vazhachal	Aug. 1982	*P. falcataria*
10.	*Goryphus* sp.	Nellai	Jan. 1981	*D. regia*
			Dec. 1982	
		Palghat	Oct. 1981	*Terminalia catappa*
11.	*Syzeuctus zanthorius* Cameron	Vazhachal	—	*P. falcataria*
12.	*Paraphylax* sp.	Vazhachal	—	*P. falcataria*
13.	*Trieces* sp.	Vazhachal	—	*P. falcataria*
14.	*Philopsyche himalayensis* Ollen	Vazhachal	Dec. 1978	*P. falcataria*
15.	*Thyracella collaris* Grav.	Vazhachal	Aug. 1982	*P. falcataria*
16.	Unidentified Gelini			
	FAMILY - BRACONIDAE			
17.	*Bracon* sp.	Vazhachal	—	*P. falcataria*
18.	*Aulosaphes* sp.	Vazhachal	—	*P. falcataraia*

TABLE 2. Percentage parasitism in some samples of *P. plagiophleps* collected from *P. falcataria* in Kerala.

Date of collection	No. of host pupae sampled			No. of parasitized pupae			parasitism %
	Male	Female	Unsexed	Male	Female	Unsexed	
24 July '78	—	—	386	—	—	98	25.4
24 July '78	—	—	78	—	—	7	9.3
9 Aug. '78	—	—	80	—	—	3	3.7
19 Dec. '78	384	371	—	79	52	—	17.4
8 Jan. '79	148	47	—	40	34	—	38.0

abundant, the impact due to parasitism was attributable mostly to these three parasitoids. All the species of parasitoids recorded in this study appear to be new reports for *P. plagiophleps* in Kerala and possibly for India. It may be mentioned here that SANKARAN (1972) also recorded several species of parasitoids belonging to the genera recorded here (*Goryphus, Brachymeria, Aulosaphes, Eurytoma* etc.) from the oilpalm bagworm *Cremastopsyche pendula* Joannis as well as an unidentified species of *Pteroma*, both of which are closely allied to *P. plagiophleps*. It seems *quite* probable that the parasite complex of these species are more identical offering great possibilities in their use in biocontrol operations.

Apart from the insects recorded here, larvae of an unidentified syrphid (Diptera) were sometimes found inside the larval bags along with dead larvae but their predatory role could not be established. It may be mentioned here that KULMAN (1965) reported 99.9% mortality of new generation in the case of *T. ephemeraeformis* due to a scavenger maggot, *Pseudogaurax anchora* (Loew) (Chloropidae) which occasionally fed on eggs. Instances of mortality of early and late instar larvae as well as pupae due to pathogenic organisms were also noticed in August 1977, July 1978 and May 1979. The high reactive humidity characteristic of these months due to rains probably is an important factor leading to attack by micro-organisms. In other bagworms, SANKARAN (1970) recorded *Paecilomyces fumosoroseus* (Wize) (on *Cremastopsyche pendula*) and *Isaria psychidae* Pole-Evans (on *A. junodi*) in Malaysia. Similarly BERISFORD & TSAO (1975) recorded 10 species of fungi pathogenic to *I. ephemeraeformis*. The role of micro-organisms in bagworm management is worth exploring.

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TWO NEW APHID PARASITOIDS (HYMENOPTERA: APHIDIIDAE) FROM GARHWAL RANGE OF WESTERN HIMALAYA, INDIA

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Two new species viz., *Pauesia* (*Paraphidius*) *lachniella* and *Pauesia* (*Paraphidius*) *orientalis* were observed to parasitize the aphids viz., *Lachnus tropicalis* and *Cinara maculipes* infesting oaks and conifers respectively in Garhwal range of western Himalaya. The present paper deals with the descriptions and the illustrations of these two new species.

(*Key words:* new aphidiid parasitoids, *Pauesia* (*Paraphidius*) *lachniella*, *Pauesia* (*Paraphidius*) *orientalis*, Garhwal Himalaya, India)

Our knowledge regarding the aphidiid fauna of Garhwal range of western Himalayas is limited. Das and Chakrabarti (1986, 1988) made some biological observations on this parasitoid group and Chakrabarti (1987) mentioned only the name of 5 aphidiid genera from this region of Himalaya. During the course of collection and rearing of aphids (1982–1985) from oak-conifer forests in Garhwal range of western Himalayas two new species were observed to parasitize the aphids viz., *Lachnus tropicalis* (van der Goot) and *Cinara maculipes* Hille Ris Lambers. This paper embodies the descriptions and illustrations of these two new species.

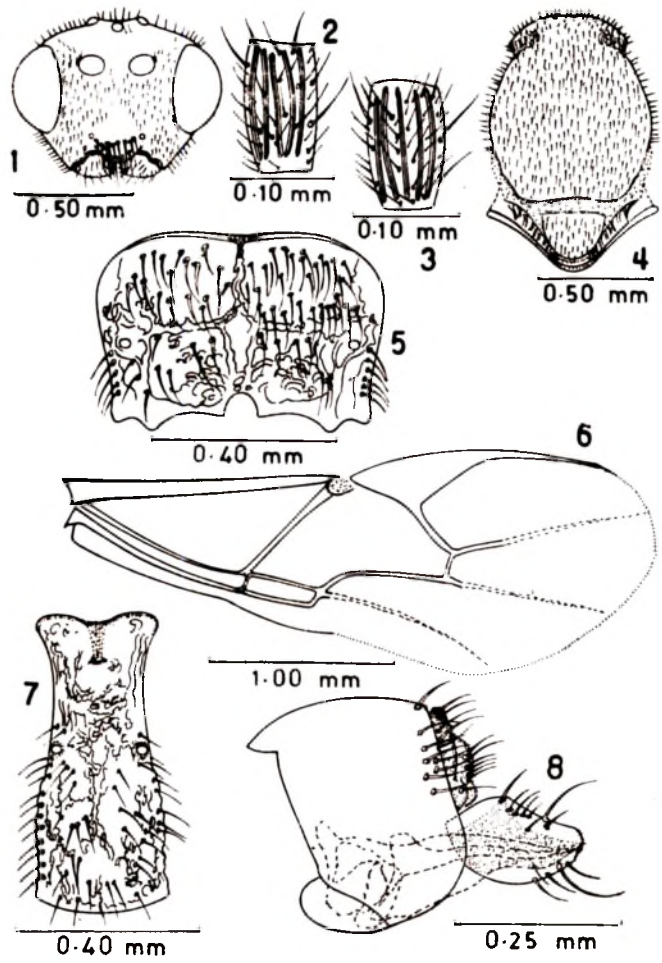
1. **Pauesia (Paraphidius) lachniella** sp. nov. (Figures 1–8)

Morphological characters:

Female: Head (Fig. 1) transverse, smooth, shiny, sparsely haired: face with dense hairs except small hairless area above clypeus; longitudinal eye diameter 2.49 ± 0.32 × width of gena; tentorial index 0.72 ± 0.06; interocular line distinctly longer than facial line, 1.33±0.09 × transfacial line; transverse eye diameter 1.50 ± 0.08 × temple; clypeus with dense long hairs. Antennae 24 segmented, reaching to the end of tergite 3; F_1 (first flagellar segment, Fig. 2) subequal to length of F_2 (Fig. 3); length of F_1 2.68±0.39 × width at base; length of F_2 2.90 ± 0.31 × width at base; all segments with sparse long hairs and dense short hairs; F_1 with 4–6 and F_2 with 3–6 rhinaria.

Mesoscutum of mesonotum (Fig. 4) with dense short hairs on disc; notaulices deeply crenulated at the ascendent part, extended with scattered sculpturing to dorsolateral disc, effaced on central disc. Scutellum comparatively small and with short hairs. Propodeum (Fig. 5) strongly descendent on posterior surface with wide transverse central areola, which is subdivided by less prominent or prominent rugosities into more or less distinct areola or areolae; upper areola with dense medium hairs and lower areola with scattered hairs.

Pterostigma of forewing (Fig. 6) triangular, length 3.00±0.25 × width, distinctly longer than length of metacarp; length of radial



Figs. 1–8. *Pauesia* (*Paraphidius*) *lachniella*, sp. nov.: Female : 1. Head; 2. First flagellar segment; 3. Second flagellar segment; 4. Mesonotum; 5. Propodeum; 6. Forewing; 7. Tergite 1; 8. Genitalia.

abscissa 1 distinctly longer than the width of pterostigma, 1.19 ± 0.06 × length of radial abscissa 2.

Length of tergite 1 (Fig. 7) 2.76 ± 0.26 × width across spiracles; surface coarsely rugose with prominent central longitudinal carina; hairs somewhat dense, medium and almost on apical half. Dorsal margin of ovipositor sheaths (Fig. 8) convex basally and then concave slightly, with 1–3 long hairs and few short hairs, maximum length 1.68 ± 0.09 × maximum width; ovipositor as in figure (Fig. 8).

Colouration: Head yellowish, except blackish brown ocellar triangle region; face deep yellowish, mouthparts light yellowish except deep brown apices of mandibles; scape dirty yellowish, pedicel dirty yellowish brown, rest of antenna portion brown except yellowish basal ring upto F_7; mesonotum (except prescutellar groove), pronotum and propleuron yell-

owish orange, mesopleuron orange brown, propodeum blackish brown; legs deep yellowish to light yellowish except brown apices of tarsi and orange yellowish tibiae of hind-legs; wing veins brown to colourless; tergite 1 brown to dirty brown, tergite 2 to 5 yellowish brown to yellowish, rest of abdomen deep blackish brown.

Body length: 4.08 ± 0.51 mm.

Measurements of one female in mm: Body length 4.00. Head: Tentorio-ocular line 0.14, intertentorial line 0.21, interocular line 0.58, facial line 0.56, transfacial line 0.44, width of gena 0.14, longitudinal eye diameter 0.34, transverse eye diameter 0.31, temple 0.20, length of antennae 2.45, length of F_1 0.12, width of F_1 at base 0.04, length of F_2 0.12, width of F_2 at base 0.04. Forewing : Length of pterostigma 0.70, width of pterostigma 0.23, length of metacarp 0.63, length of radial abscissa 10.32, length of radial abscissa 20.27. Tergite 1 : Length 0.62, width across spiracles 0.22. Ovipositor sheaths : Maximum length 0.21, maximum width 0.13.

Male: Antennae 27 segmented, body length 3.68 ± 0.21 mm, colouration darker than the female, otherwise like the female except sexual differences.

Mummy : Yellowish gray.

Holotype: ♀: INDIA : UTTAR PRADESH Sakri (*c* 1800 m), ex. *Lachnus tropicalis* (van der Goot) on *Quercus dealbata* Hook, 29. iv. 1984 (coll. B. C. Das) **Paratypes :** 17 females and 10 males, collection data as in the holotype.

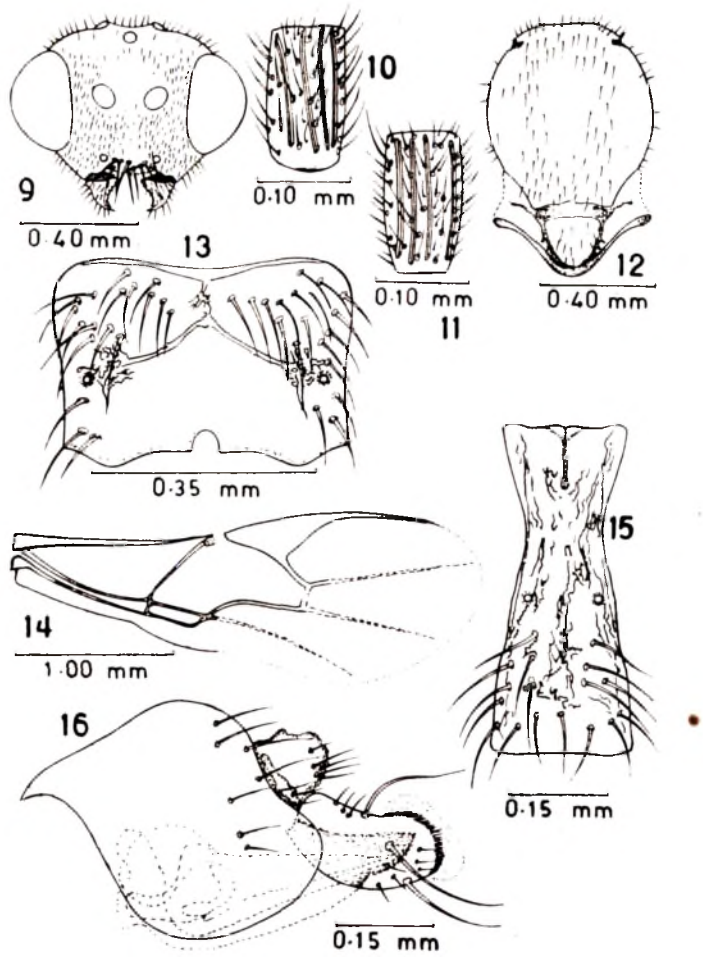
Remarks : This new species is closely related to *P.* (*P.*) *indica* Stary (in Stary & Raychaudhuri, 1977) in having same number of antennal segments and sculptures on propodeum and shape of the ovipositor sheaths. But it can be differentiated from the latter species by the following characters: (i) Temple equal to 0.65 of transverse eye diameter instead of 0.50, (ii) F_1 with 4–6 and F_2 with 3–6 rhinaria instead of 0 and 1 respectively, (iii) mesoscutum with dense short hairs instead of sparse long hairs, (iv) pterostigma distinctly longer than the length of metacarp instead of equal, (v) radial abscissa 1 distinctly longer than width of pterostigma instead of somewhat longer, (vi) tergite 1, 2.50 as long as wide across spiracles instead of 2, and (vii) some minor colour variations on different body parts.

2. Pauesia (Paraphidius) orientalis sp. nov. (Figures 9–16)

Morphological characters:

Female : Head (Fig. 9) transverse, smooth, shiny, somewhat densely haired; face with also dense hairs except a narrow longitudinal hairless area above the clypeus; longitudinal eye diamter 2.68 ± 0.21 × width of gena: tentorial index 0.75 ± 0.08: interocular line distinctly longer than facial line, 1.40 ± 0.09 × transfacial line: transverse eye diameter 2.00 ± 0.27 × temple: clypeus with 8–10 comparatively short hairs. Antennae 22 segmented, reaching to the middle of tergite 3; F_1 (Fig. 10) subequal to length of F_2 (Fig. 11); length of F_1 2.20 ± 0.11 × width at base; length of F_2 2.50 ± 0.28 × width at base : all segments with sparse long hairs and dense short hairs; F_1 with 3–5 and F_2 with 2–4 rhinaria.

Mesoscutum of mesonotum (Fig. 12) with sparse hairs almost in two longitudinal rows on disc; notaulices wide, deeply crenulated, distinct at the ascendent part, effaced on disc; scutellum somewhat narrow, lateral margin sculptured, rugose and with few hairs on disc. Central areola on propodeum (Fig. 13) medium sized: lateral longitudinal carinae extended



Figs. 9–16. *Pauesia* (*Paraphidius*) *orientalis* sp. nov. : Female : 9. Head; 10. First flagellar segment; 11. Second flagellar segment; 12. Mesonotum; 13. Propodeum; 14. Forewing; 15. Tergite 1; 16. Genitalia.

more or less half distance between spiracles and lower margin of propodeum; coarsely rugose with many irregular sculpturing carinae near the junction of lateral and transverse carinae (near spiracles); upper areola with dense long hairs.

Pterostigma of forewing (14) triagular, length $2.70 \pm 0.21 \times$ width, subequal to the length of metacarp; length of radial abscissa 1 distinctly shorter than the width of pterostigma, subequal to the length of radial abscissa 2.

Length of tergite 1 (Fig. 15) $3.17 \pm 0.25 \times$ width across spiracles; surface coarsely rugose, irregularly crenulated throughout; lower portion with few long hairs. Dorsal margin of ovipositor sheaths (Fig. 16) concave, maximum length $2.15 \pm 0.17 \times$ maximum width, with 2–3 abnormal long hairs on its lateral surface and the apex of the sheaths densely pubescent; ovipositor as in figure (Fig. 16).

Colouration: Head yellowish brown except dark brown ocelli region; face deep yellowish

mouthparts light yellowish except brown apices of mandibles; scape yellowish, pedicel brown, basal ring of F_1 yellowish, rest of antennae deep brown: mesoscutum, pronotum, propleuron almost orange brown except two dark brown bands near prescutellar groove on mesoscutum, rest of thorax blackish brown; front legs deep yellowish brown except deep brown tarsi, hind-legs yellowish orange to deep brown; wing veins brown to colourless; tergite 1 dark brown, basal portion of ovipositor sheaths blackish brown, apical portion of ovipositor sheaths brown, rest of abdomen brown to yellowish.

Body length : 3. 36±0.40 mm.

Measurements of one female in mm: Body length 3.50. Head: Tentorio-ocular line 0.12, intertentorial line 0.17, interocular line 0.51, facial line 0.47, transfacial line 0.38, width of gena 0.13, longitudinal eye diameter 0.33, transverse eye diameter 0.27, temple 0.14, length of antennae 2.69, length of F_1 0.15 width of F_1 at base 0.07, length of F_2 0.15, width of F_2 at base 0.06. Forewing: Length of pterostigma 0.60, width of pterostigma 0.22, length of metacarp 0.59, length of radial abscissa 1, 0.19, length of radial abscissa 2, 0.18. Tergite 1: Length 0.47, width across spiracles 0.15. Ovipositor sheaths : Maximum length 0.23, maximum width 0.11.

Male : Unknown.

Mummy : Blackish brown.

Holotype: ♀: INDIA : UTTAR PRADESH, Tapaban (*c* 1829 m), ex. *Cinara maculipes* Hille Ris Lambers on *Pinus excelsa* Wall., 15. vii. 1983 (coll. B. C. Das). **Paratypes :** 4 females, collection data as in the holotype.

Remarks: This new species in having 22 segmented antennae, arrangements of hairs on mesoscutum, relative length and width (at spiracles) of tergite 1 comes close to *P.* (*P.*) *rufithorax* Stary & Remaudiere (1982), but differs from the latter species by the characters of female genitalia. In *rufithorax* the ovipositor sheaths are more or less square and its apex with a few short hairs.

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PRAON HIMALAYENSIS, A NEW WALNUT APHID PARASITOID (HYMENO PTERA: APHIDIIDAE) IN GARHWAL RANGE OF WESTERN HIMALAYAS

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Praon himalayensis, **a new Aphidiid parasitoid infesting the Dusky-veined Walnut aphid,** *Callaphis juglandis* **(Geoze) in the Garhwal Range of Western Himalayas is described and figured.**

(*Key words:* aphidiid parasitoid, new species, western Himalayas, India)

Walnut (*Juglans regia* Linn.) is an economically important deciduous fruit yielding tree in Garhwal range of western Himalayas. This tree is severely damaged by the tremendous infestation of the aphid *Callaphis juglandis* (Goeze) not only in India but also in serveral other countries. During a study from 1982–1985 for aphid parasitoids, the present new species was collected from the aforesaid range of Himalayas and described here.

Praon himalayensis sp. nov. (Figs. 1–9)

Female : Head (Fig. 1) : Subquadrate, smooth, shiny, sparsely haired; face with a narrow longitudinal area which is bordered by simple rows of hairs, the area between the rows and orbits with sparse hairs; longitudinal eye diameter $5.23 \pm 0.53 \times$ width of gena; tentorial index 0.28 ± 0.06; interocular line subequal to facial line, $2.05 \pm 0.07 \times$ transfacial line; transverse eye diameter $1.25 \pm 0.09 \times$ temple; clypeus with 14–19 medium hairs. Antennae 15–16 segmented, reaching to the end of tergite 2 ; first flagellar segment (F_1) (Fig. 2) $1.50 \pm 0.17 \times$ length of F_2 (Fig. 3), length of F_1 $4.18 \pm 0.44 \times$ width at base; length of F_2 $3.06 \pm 0.34 \times$ width at base; F_1 and F_2 without rhinaria.

Thorax : Mesoscutum of mesonotum (Fig. 4) falling vertically into pronotum; central lobe comparatively densely haired, lateral lobes with large hairless area; notaulices effaced near prescutellar groove. Scutellum wide and with dense short hairs on disc. Propodeum (Fig. 5) smooth, without carina and with sparse and dense short hairs.

Forewing (Fig. 6) : Pterostigma triangular, length $3.35 \pm 0.35 \times$ width. $2.08 \pm 0.18 \times$ length of metacarp; length of radial vein $1.45 \pm 0.15 \times$ width of pterostigma, little shorter than the length of metacarp.

Abdomen: Length of tergite 1 (Fig. 7) $1.40 \pm 0.11 \times$ width across spiracles; dorsal surface somewhat smooth, with a few long and dense short hairs on laterodorsal plains. Ovipositor sheaths (Fig. 8) oblong, with 2 nail form hairs apically, maximum length

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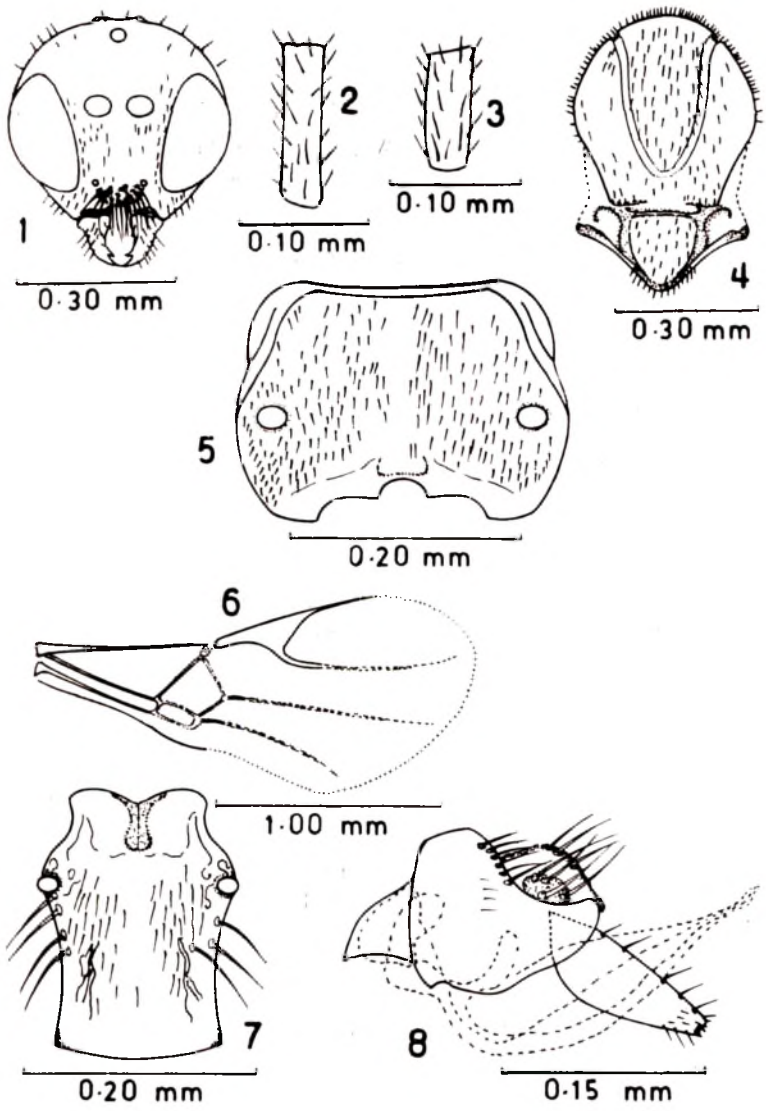

Figures 1–9. *Praon himalayayensis* sp. nov. Female 1. Head; 2. First flagellar segment; 3. Second flagellar segment; 4. Mesonotum; 5. Propodeum; 6. Forewing; 7. Tergite-1 8. Genitalia.

$2.70 \pm 0.14 \times$ maximum width; ovipositor lanceolate.

Colouration: Head blackish brown; face dirty brown; mouthparts yellowish except brown apices of mandibles; scape, pedicel and F_1 yellowish, rest of antennal portion brown thorax blackish brown except dirty deep brown propodeum; legs deep yellowish except yellowish orange coxa, apices of tarsi; wing veins brown to colourless; tergite 1 dirty yellowish brown, ovipositor sheaths blackish to dirty yellow, rest of the abdomen dirty yellowish to yellowish.

Body length: 2.25 ± 0.16 mm.

Male: Antennae 18 segmented, body length 2.04 ± 0.09 mm, F_1 with 6 and F_2 with 6–7 rhinaria, colouration generally darker than the female, otherwise like the female except sexual differences.

Mummy (Fig. 9): Cocoons of the parasitoids are yellowish white; mummified aphids yellowish brown.

Holotype: ♀; INDIA : UTTAR PRADESH, Joshimath (c 1875 m), ex. *Callaphis juglandis* (Goeze) on *Juglans regia* Linn., 12.v.1985 (Coll. B.C. Das). **Paratypes:** 30 females and 18 males, other data same as holotype except collection dates (12.v.1985; 20.v.1985; 29.v.1985). All types are in the collections of Biosystematics Research Unit, Department of Zoology, University of Kalyani.

Fig. 9. *Praon himalayensis* sp. nov.: Mummified aphids.

Remarks: This new species in having tentorial index 0.22—0.34, hair arrangement on lateral lobes of mesoscutum, pterostigma 3.00—3.70 times as long as wide and host range comes close to *P. callaphis* Mackauer & Sullivan (1982). However, *P. callaphis* differs from *P. himalayaensis* sp. nov. in having 12–14 segmented antennae; length of F_1 somewhat longer than the length of F_2; notaulices on mesoscutum throughout distinct; length of radial vein slightly longer than width of pterostigma besides some colour variations on different body parts.

This parasitoid generally appears in the field when the aphid population attains its peak. It starts to parasitize its hosts scatteredly and within a short time their number rises to its peak. As a result, the population of *C. juglandis* decimates. Thus, this parasitoid may be manipulated as biocontrol agent against the aforesaid pest.

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PRELIMINARY NOTE ON THE PARASITOIDS OF *MUSCA DOMESTICA* (DIPTERA: MUSCIDAE) IN PONDICHERRY

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(*Received* 12 *November* 1988)

A survey was carried out to find out the natural enemies of housefly, four species of pupal parasitoids viz., *Pachycrepoideus vindemmiae*, *Splangia cameroni*, *Splangia nigroaenea* and *Dirhinus himalayanus* were collected from different habitats such as cattle shed, poultry farm and piggery farm in Pondicherry between February 1984 and January 1985. The prevalence of parasitoids was high during May - September 1984. Of all the parasitoids *D. himalayanus* is being recorded for the first time in South India.

(*Key words:* survey of parasitoids, *Musca domestica*)

INTRODUCTION

The role of housefly, *Musca domestica* Linnaeus (Diptera: Muscidae) in the transmission of bacteria, fungus, virus and protozoan mechanically among men and cattle is well known from time immemorial and diseases such as enteric infection, dysentry, diarrhoea, typhoid, food poisoning are being propagated by house flies (GREENBURG, 1971). To control the fly-borne diseases, in the past much emphasis had been laid on chemicals. However, development of resistance in flies and accumulation of residues in tissues of treated fowls, cattle and adverse effect on non-target organisms necessitated the need to find out an alternate method to suppress the fly population. During the last two decades attention has been directed towards biological control in which natural enemies play an integral part in controlling filth breeding flies. Hence an attempt was made to explore the occurrence, abundance and distribution of natural enemies of housefly in Pondicherry region and the results are presented.

MATERIALS AND METHODS

Systematic surveys were carried out once a month in different habitats such as piggery farm, situated in Koodapakkam, a village in Pondicherry where about 50 pigs are being maintained, poultry farms in Auro-orchard, where battery system is being practised and cattle sheds located in Pillayarkuppam, where about 100 cattle are being maintained. Samples of manure were collected from all these habitats and brought to laboratory. Puparia isolated from dung samples employing floating and skimming methods were kept in containers for the possible emergence of parasitoids and/or flies under controlled temperature (28 ± 2°C and RH 60–75%). Records were maintained on the emergence of fly and parasitoids. Specimens obtained from the field collected puparia were sent to Commonwealth Institute of Entomology, London for identification.

RESULTS AND DISCUSSION

The total number of puparia collected from all the habitats was 2661, out of which, 208

were collected from piggery farm, 593 from poultry farm and the remaining 1860 from dairy farm. *Musca domestica* (71.9%) is the predominant species found breeding in all these habitats and was followed by a few species each of *Stomoxys calcitrans* (8.9%), *Fannia* sp. (6.5%) and *Drosophila* sp. (12.7%).

The species of parasitoids obtained from the field collected puparia of houseflies were *Spalangia cameroni*, Perkins (Hymenoptera: Pteromalidae); *Spalangia nigroaenea* Curtis (Hymenoptera: Pteromalidae); *Pachycrepoideus vindemmiae* Rondani (Hymenoptera: Pteromalidae) and *Dirhinus himalayanus*, West Wood (Hymenoptera : Chalcididae).

Though the occurrence of *S. cameroni*, *S. nigroaenea* and *P. vindemmiae* was reported already (GEETHABAI & SANKARAN, 1977), *D. himalayanus* is being reported for the first time from South India.

S. cameroni and *S. nigroaenea* were common in dairy farm, found parasitizing the fly puparia in the accumulation of cow dung and *D. himalayanus* was prevalent only in poultry farm, whereas *P. vindemmiae* was noticed in all the habitats. The highest density of these parasitoids during summer months coincides with that of the density of the host, which was also found to breed abundantly during June, July and August (Table).

The density and seasonal pattern of parasitoids show a correlation with rainfall and temperature (DONALD & AXTELL, 1980). The density of parasitoids increases with increase in temperature reached a peak during June, July and August and decreased there-

TABLE 1. Details of housefly and parasitoids emerged from the puparia collected from different habitats.

Month	Piggery				Poultry					Cattle shed					
	Tl.no. of puparia	No.of flies emerged	Natural mortality of flies	P.v.	Tl.no. of puparia	No.of flies emerged	Natural mortality of flies	P.v.	D.h.	Tl.no. of puparia	No.of flies emerged	Natural mortality of flies	P.v.	S.c.	S.n.
Feb. 84	3	3	0	0	23	23	0	0	0	25	25	0	0	0	0
Mar.	12	12	0	0	56	53	3	0	0	92	87	2	0	3	0
Apr.	26	24	2	0	62	56	1	3	2	137	119	6	0	9	3
May	47	47	0	0	75	66	8	0	1	216	199	10	0	5	2
Jun.	43	29	2	12	117	101	7	5	4	325	268	12	12	18	17
Jul.	48	38	7	3	147	112	12	17	6	317	259	7	9	20	22
Aug.	17	11	0	6	66	58	3	3	2	302	253	6	7	15	21
Sep.	7	7	0	0	15	13	0	1	1	264	223	4	12	5	20
Oct.	0	0	0	0	0	0	0	0	0	141	116	3	5	3	14
Nov.	0	0	0	0	10	9	0	0	1	17	14	1	0	0	2
Dec.	0	0	0	0	7	7	0	0	0	15	15	0	0	0	2
Jan. '85	5	5	0	0	15	14	1	0	0	9	9	0	0	0	0

P. v. – *P. vindammiae* S. c. – *S. cameroni*
D. h. – *D. himalayanus* S. n. – *S. nigroaenea*

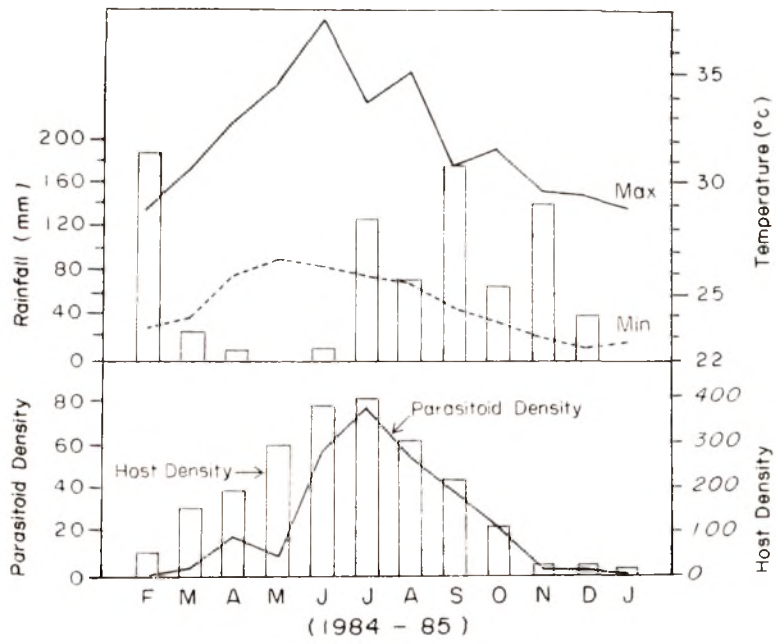

Fig. 1. Seasonal fluctuation of host and parasitoid densities (combined number of all species in all habitats).

after. Seasonal fluctuation of host and parasitoid densities were shown in Fig. 1.

The advent of North East monsoon during September to November adversely affected the house fly density. Heavy rainfall had a negative influence on immatures, which were usually flushed away and resulted in the decline of both host and parasitoid density. It is well known that the parasitoids can be released *en masse* when the host density is low. The study suggests that the parasitoids can be released during post-monsoon period for effective control of houseflies.

It was reported earlier that *Spalangia* species are the favoured biological control agent, due to their adaptation to varied environmental conditions (LEGNER, 1977). The present study shows that *P. vindemmiae* is a more promising biological control agent against the houseflies due to their better adaptability to varied habitats and climatic conditions. Though the parasitoids occur in nature augmentative releases on a sustained manner will keep the fly population under check in an integrated pest management programme.

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ON THE INNERVATION OF THE PROTHORACIC GLANDS IN THE PLAIN TIGER BUTTERFLY *DANAIS CHRYSIPPUS* LINN.

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The prothoracic glands in the V instar larva are innervated by branches of 3 pairs of nerves given out by the prothoracic ganglion and second interganglionic connectives. While severance of all these nerves had no effect on moulting, severance of N_3 alone inhibited fusion of pro- and mesothoracic ganglia by preventing shortening of the connectives between them.

(*Key words:* innervation, prothoracic glands, *Danais*)

INTRODUCTION

Innervation of the prothoracic glands (PTG) in Lepidoptera has been studied by several workers (HERMAN & GILBERT, 1966; HINTZE-PODUFAL, 1970; SINGH, 1975; SRIVASTAVA et al., 1977; GRANGER, 1978; AWASTHI & SINGH, 1983; TIWARI et al., 1987). While most of these works are confined to moths, the butterflies, their allies have been paid very little attention (SRIVASTAVA et al., 1977). Besides, a great deal of diversity exists also in the function of innervation (see discussion). In this communication we have described the innervation of the PTG and examined its role in the plain tiger butterfly, *D. chrysippus*.

MATERIALS AND METHODS

Early larval instars were collected from fields and reared in the laboratory on fresh leaves of common AK plant, *Calotropis* spp. Young V (ultimate) instar larvae, which were utilised in the present study, were dissected in physiological saline and the nerves innervating the PTG were stained intravitally with methylene blue. All the nerves supplying the glands were severed in water-narcotised insects. The surgical procedures and post-surgical treatments were the same as in our earlier work (SRIVASTAVA et al., 1977).

RESULTS

Innervation of the PTG:

The PTG are paired, one cell thick, triradiate and flattened mass of gland cells lying dorsal to the ventral tracheal trunk (TR) close to the first thoracic spiracle. The main body of the gland is supported at its base by a horizontally situated muscle band. The gland on each side is innervated by 3 nerves designated as N_1, N_2 and N_3 (Fig. 1). The N_1 arises from the prothoracic ganglion (T_1) and runs obliquely towards the apex of the gland giving two branches on the way to segmental muscles. After giving a minor branch to the bifid arm of the gland, the nerve proceeds further to innervate the muscles and body wall. The N_2, which is a transverse branch of the first median nerve (MN_1), receives a very thin branch from the N_3 arising from second interganglionic connectives (IC_2). The composite nerve, thus formed, innervates the postero-lateral margin of the gland while the main trunk of the N_3 supplies to the muscles and body wall of this region. The nerves

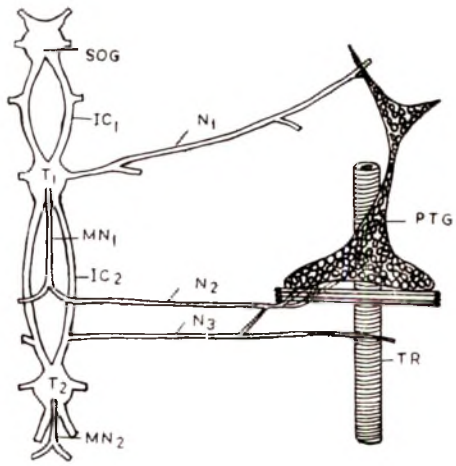

Fig. 1. Diagram showing the innervation of the prothoracic gland in the larva of *Danais chrysippus* (For lettering see text).

arising from the suboesophageal (SOG) and mesothoracic ganglia (T_2) and that from the first interganglionic connectives (IC_1) do not supply the gland.

Effect of nerve- severance:

Sectioning of all the 3 pairs of nerves supplying the glands do not produce any apparent effect on the development and metamorphosis though it does not allow the T_1 and T_2 to fuse by preventing the shortening of IC_2 which usually occurs in normal adults. Obviously, one or more of the above three nerves could have produced this effect. Therefore, we severed the nerves individually to determine whether any particular nerve was involved and it was found that the N_3 alone was concerned in bringing about this change as shown in the Table 1.

DISCUSSION

In *D. chrysippus* each PTG is innervated by 3 nerves–2 nerves arising from the T_1 and the remaining one from the IC_2 whereas in the other, perhaps the only butterfly studied, *Papilio demoleus*, SRIVASTAVA et al. (1977) have described 5 pairs of nerves supplying the glands; one nerve arising from SOG, 2 from T_1 and one each from IC_1 and IC_2. Similarly in moths, the innervation varies greatly but at least 2 thoracic ganglia have always been found associated with the glands (see AWASTHI & SINGH, 1983). In *D. chrysippus*, exceptionally, only one thoracic ganglion (prothoracic) is concerned with the innervation of its PTG.

The significance of innervation is not yet well understood. On the basis of existing knowledge about the PTG, it is proposed that the nerves innervating the glands are involved either in the regulation of moulting process (POSSOMPES, 1953) or in serving a sensory pathway for the proprioceptive input to the brain (EDWARDS, 1966; SRIVASTAVA et al., 1977) or in inhibiting the glandular function (HERMAN & GILBERT, 1966; ALEXANDER, 1970; MALA et al., 1977) or in transporting

TABLE 1. Effect of severance of the prothoracic gland nerves in the larva of *D. chrysippus*.

Nerves severed	No. larvae	No. survived	% survival	No. moulted	Other effects
$N_1 - N_3$	50	40	(80)	40	IC_2 uncondensed
N_1	25	22	(88)	22	,, condensed
N_2	30	24	(80)	24	,, ,,
N_3	30	27	(90)	27	,, uncondensed
Controls	25	23	(92)	23	,, condensed

neurosecretory type of granules to the gland cells (SRIVASTAVA & SINGH, 1968; HINTZE-PODUFAL, 1970; YIN & CHIPPENDALE, 1975). In *D. chrysippus* denervation of the gland failed to cause any adverse effect on development and metamorphosis except preventing the shortening of IC_2. This led us to presume that the innervation of the gland arising from N_3 forms a part of the general nervous system meant to integrate the functions of different body segments and has no specific role in the activity of the glands as reported by us earlier (TIWARI et al., 1987).

With regard to the failure of connective-shortening after N_3 sectioning, PIPA (1967) stated that it is controlled by a blood- borne factor. Furthermore, ROBERTSON & PIPA (1973) in *Galleria mellonella* and SINGH & SRIVASTAVA (1973) in *Philosamia ricini* observed an extensive degradation of the neural lamella (NL) in connectives which were shortening. It has been suggested that the N_3 in the present insect possibly produces sensory stimuli (specific to the degradation of NL) to the brain which, in turn, in absence of the stimulus (after N_3 sectioning) fails to release the requisite factor needed for degradation of the lamella and hence no connective–shortening occurs.

ACKNOWLEDGEMENTS

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BRIEF COMMUNICATION

NEW RECORD OF *PANTHOUS BIMACULATUS* (HEMIPERA: REDUVIIDAE) AS A PREDATOR OF PESTS OF *AILANTHUS TRIPHYSA*

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(*Received* 10 *May* 1989)

A reduviid bug, *Panthous bimaculatus*, is reported for the first time as an insect predator.

(*Key words:* *Panthous bimaculatus*, predator, pests of *Ailanthus*)

Two major pests of *Ailanthus*, a fast growing tree genus (Family – Simarubaceae), are *Atteva fabriciella* Swed. (Lepidoptera : Yponomeutidae) and *Eligma narcissus* (Lepidoptera: Noctuidae). Some aspects of ecology and possible control of these pests are being carried out (VARMA, 1986). However, detailed information on the biological control agents of the two pests is lacking. While studying the natural enemy complex of the two pests in selected *A. triphysa* plantations at Thattekkad and Mullaringad (Kothamangalam Forest Division) in Kerala, a reduviid bug was found during October 1987, feeding on larvae of both the pests.

The bug was identified as *Panthous bimaculatus* Distant. This belongs to the subfamily Harpactorinae of the family Reduviidae. The genus *Panthous* is represented by two species in India – *P. excellens* from Naga Hills in Nagaland and *P. bimaculatus* from Trivandrum in Kerala (DISTANT, 1904). The adult bug measures 20–25 mm. The colour of head, pronotum, rostrum, coxae and legs is brownish red, whereas the antennae, tip of the rostrum and under surface of the body are black.

KFRI Scientific Paper No. 171.

Field collected *P. bimaculatus* were successfully reared in the laboratory on larvae of either *E. narcissus* or *A. fabriciella*. Based on preliminary forced feeding experiments it appears that the bugs prefer the former because of the larger quantity of body fluids present compared to the lower quantity present in *A. fabriciella*. When a 3-day starved adult *P. bimaculatus* was offered other lepidopteran larvae – *Hyblaea puera* (Hyblaeidae) a pest of teak and *Hypsipyla robusta* (Phycitidae) a pest of mahogany, both were not acceptable to the bug. So also, the bugs did not feed on dealated adult termites when offered in the laboratory. Under laboratory conditions an adult bug normally fed on one *E. narcissus* larva per day and rarely 2 whereas it consumed 2–3 larvae of *A. fabriciella* per day. A larva of *E. narcissus* weighing 460 mg was drained out in about 45 minutes. Once fed, the bugs did not bother to predate on another larva immediately. The adult bugs survived without any food for over 20 days in the laboratory.

Though there is lot of information available on Indian reduviids and their role as predators (AMBROSE 1987; HARIDAS & ANANTHAKRISHNAN, 1980), there is no mention of

P. bimaculatus as an insect predator until now. The fact that this predatory bug can thrive on both the pests indicates that it can survive in an *Ailanthus* plantation very well because one or both the pests will be present during most of the months in an year. The added advantage of its possible selective feeding on the two pests further makes it an ideal biological control agent against *E. narcissus*/*A. fabriciella*. Further aspects such as rearing, biology, ecology and predatory potential of *P. bimaculatus* are under investigation.

The author is thankful to Dr. M. S. K. GHAURI of the CAB International Institute of Entomology, London for identifying the reduviid bug.

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BRIEF COMMUNICATION

RECORD OF WAX SCALE *CEROPLASTES FLORIDENSIS* COMSTOCK (HOMOPTERA: COCCIDAE) INFESTING CLOVE SEEDLINGS IN KERALA, INDIA[1]

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(*Received* 10 *March* 1989)

***Ceroplastes floridensis* Comstock (Homoptera : Coccidae) has been recordef for the first time infesting clove seedlings in Kerala, India.**

(*Key words:* wax scale, *Ceroplastes floridensis*, clove, *Eugenia caryophyllus*)

Among the insect pests recorded on clove (*Eugenia caryophyllus* (Sprengel) Bullock *et* Harrison) in India, scale insects are important pests especially on seedlings and younger plants. The various species recorded on the crop include *Parasaissetia nigra* (Nietner) (ABRAHAM *et al.*, 1970), *Mycetaspis personata* (Comstock) (NAIR *et al.*, 1977) *Lecanium psidii* (ANONYMOUS, 1981) and *Pulvinaria psidi* Maskell (VISALAKSHI *et al.*, 1981). During March 1985 infestation of the wax scale *Ceroplastes floridensis* Comstock (Homoptera : Coccidae) on 2 year old seedlings of clove in the nursery at the farm of the National Research Centre for Spices at Peruvannamuzhi (Calicut district, Kerala). This is recorded on clove for the first time.

The scales were observed on tender shoots and lower surface of tender leaves. The infested leaves became discoloured, wilted and dropped; when control measures were not undertaken some of the seedlings wilted and died. In a sample of 1162 plants observed on 12th March 1985, 11.7 percent of them were infested. The mature scales were oval, convex and greyish white with a waxy plate and measured 2.62×1.83 mm ($n = 5$) (Fig. 1). Eggs were observed under some of the scales and they were oval and measured 0.29×0.16 mm ($n = 5$).

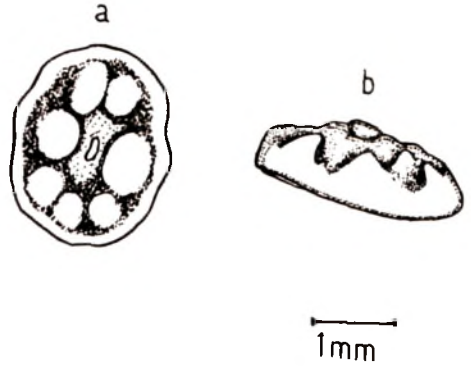

Fig. 1. Adult of *Ceroplastes floridensis* (a. dorsal view b. lateral view).

C. floridensis is a well known polyphagous pest in India occurring on fruit trees like apple, citrus, custard apple, fig, guava, mango and other crops such as cashew, okra and tea (NAIR, 1975; BUTANI, 1979). The pest infestation could be controlled by spraying monocrotophos 0.05 percent.

[1]Contribution No. 114 of National Research Centre for Spices, Calicut-673 012, Kerala.

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We are thankful to Dr. D. J. Williams of the CAB International Institute of Entomology, London for identification of the pest.

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BRIEF COMMUNICATION

UZIFLY INFESTATION ON YOUNG AGE SILKWORMS OF *BOMBYX MORI* L. IN TAMIL NADU, INDIA

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Uzifly (*Exorista bombycis* (Louis) hitherto reported as parasitic on silkworm (*Bombyx mori* L.) larvae after III moult has been now reported to parasitise silkworm larvae in chawkie stage, during first and second instars. This is the first report from silkworm mortality due to uzifly during chawkie stage.

(*Key words:* *Bombyx mori*, *Exorista bombycis*, parasitic on young age worms)

Hitherto Uzifly (*Exorista bombycis* (Louis)) (Ghorpade, 1986) has been reported to infest on three species of silkworms viz. *Bombyx mori* L. (mulberry silkworm), *Antheraea assama* Westw. (muga) and *Philosamia ricini* Hutt. (Eri). As a rule, worms are attacked only when they have passed third or fourth moult (JAMESON, 1984). In the first and second instars, silkworms are seldom hosts to this fly pest as they are too small and hence not sufficiently attractive to the fly pest and the young stages of silkworms are practically free of infestation (KRISHNASWAMI *et al.*, 1973).

This pest was unknown in South India until May 1980 when the tachinid was introduced through human agency (by transport of parasitised bivoltine cocoon) from West Bengal to Karnataka (GHORPADE, *op. cit.*). Along with the rapid development of sericulture in South India especially in Tamilnadu, during past 3–4 years this pest took momentum and spread to almost all the newly developed sericultural area.

During the course of last two years sericultural extension work, uzi infestation on first and second age silkworms was noticed at P. M. Palayam (11°5'N Lat. 78°4'E long.) in Salem District of Tamil Nadu, one of the chawkie rearing centres under Regional Sericultural Research Station, Salem. Uzifly infestation during April month was heavy and a major portion of silkworm bed at second instar larvae appeared pale yellow to blackish in colour due to heavy mortality of silkworms. This period of heavy uzi infestation coincided with the period of maximum fecundity of uzifly (PATIL & GOVINDAN, 1986). It has earlier been presumed that under compulsion, uzifly may lay eggs even on younger silkworms (JOLLY, 1981). But this is probably the first field evidence of uzi infestation on young age silkworm. High fecundity in April resulted in oviposition on chawkie worms due to non-availability of sufficient number of later age silkworms in the field. Also several farmers are using nylon net enclosure as a physical prophylactic measure to control uzifly and hence the gravid uzifly females lay eggs on chawkie worms which are generally not covered with nylon net.

Fifteen random samples of second age silkworms from five rearing trays of chawkie rearing centre were isolated. Uzi affected and healthy silkworms were counted and compared. Infestation was found to be as high as 60%. Most of the affected worms had a single scar on the head or on the

first segment of the thorax. Silkworms in first and second age have more prominent head as compared to the abdominal part. Uzifly, therefore, preferred head region or near head region for alighting and laying eggs. Uzi maggots emerged from the eggs subsequently made their entry into the body of silkworm through thoracic segment. Most of the affected silkworms, due to their smaller size, died within one or two days. Studies on further developmental processes of uzi maggots within the chawkie stage of silkworm are in progress.

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BRIEF COMMUNICATION

GUAVA AS A POTENTIAL HOST OF *PARADASYNUS ROSTRATUS* DIST. (COREIDAE) THE COREID BUG OF COCONUT IN KERALA

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(*Received* 4 *September* 1988)

The biology of *Paradasynus rostratus* Dist. (Coreidae: Hemiptera) has been worked out on guava. The life cycle is completed in 60–80 days. Guava is found to be a potential host of this species which is a serious pest of coconut in Kerala.

(*Key words:* *Paradasynus rostratus*, Guava)

Paradasynus rostratus Dist. (Coreidae: Hemiptera) has been reported by NAIR & REMAMONY (1964) infesting tender cashew nuts and as pest of coconut by KURIAN *et al.* (1972). Though guava (NAIR, 1975) and tamarind (KURIAN, 1979) have been reported as alternate hosts of *P. rostratus*, detailed information on the biology and nature of damage of this bug on these hosts are not available. Moreover guava is found to be a potential host of this pest which is now becoming a serious menace to coconut cultivation in Kerala. Hence studies were undertaken in the College Farm, during 1984–1985 on the life cycle and feeding habits of *P. rostratus* on guava, the results of which are presented in this paper.

The adult bugs collected from guava plants were confined in cylindrical glass jars (25 cm $\times$ 15 cm) containing guava twigs with fresh fruits, kept in conical flasks containing water. The observations on mating, egg laying and other characteristics were observed in the laboratory.

Oviposition:

Mating takes place 7 to 9 days after emergence of adults. Eggs are laid in clusters well arranged on tender guava fruits or sometimes on leaves or on branches. The female while laying the eggs twists the abdominal end for 45 seconds and then it is lifted and the eggs laid. It takes about 50 seconds for a single egg to be laid. The egg is elongate oval, orange yellow in colour when freshly laid; towards hatching the colour changes to dark red with golden tinge and the egg hatches out within 8–10 days. By pushing the operculum the small nymph comes out of the egg.

The nymphs:

The first instar nymphs are reddish in colour and they remain clustered on the fruit or leaf just near the egg cages till moulting takes place. The biometric observations and duration of immature stages are given in Table 1. In the antenna, the third segment is flat and broader than the other segments which is characteristic of this bug. The total life cycle has a duration of 60–80 days. The colour of the nymphs changes to dark brown in the final instar with well developed wing pads.

The adult:

The adult is deep pink in colour soon after moulting from the final nymphal instar and

TABLE 1. Biometrics and life-cycle of *P. rostratus* on guava.

Stage	Length of body: range (mm)	Thoracic width:range (mm)	Length of antennae: range (mm)	Duration in days Mean
Egg	1.5–1.75	0.75–0.90		9
1st instar	2.5–3.00	0.75–1.0	2.5–3.0	3
2nd instar	3.5–5.0	1.0–1.25	5.5–7.0	9.2
3rd instar	7.5–8.5	1.75–2.0	9.0–10.0	4.9
4th instar	8.5–9.5	2.25–2.5	10.0–11.0	7.1
5th instar	10.0–13.0	2.75–3.0	13.0–14.0	4.5
Adult female	21.0–22.0	7.0	20.0–21.0	3.0
Male	15.0–17.0	5.0	15.0–16.0	

gradually changes to chocolate brown. Adults are active fliers. Adult longevity varies from 25–35 days.

Feeding habits and nature of damage caused:

The nymphs and the adults feed on the guava fruits. The first and 2nd instar nymphs remained congregated and from the third instar onwards they get distributed and attack individual fruits. The feeding time extends upto 40–50 minutes continously without withdrawing the stylet. As a result of feeding the fruits become malformed. When the damaged fruits are cut open dark brown hard areas are seen in the pericarp, the discolouration extending upto the endocarp. In the areas through which feeding occurs the developing ovary is also affected. Formation of hard areas, and suppression of ovule development takes place resulting in the formation of malformed fruits.

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Thanks are expressed to Prof. A. T. ABRAHAM, Dept. of Agricultural Botany for his valuable guidance and to Mrs. Kumar, Trivandrum for providing a continous supply of the coreid bugs from the guava plants in their garden.

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BRIEF COMMUNICATION

RELATIVE TOXICITY OF INSECTICIDES TO RICE BUG *LEPTOCORISA ACUTA* THUNB

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(*Received* 4 *September* 1988)

In laboratory bio-assay of 12 insecticides, malathion, formothion, fenthion and methyl parathion ranked superior in toxicity to rice bug *Leptocorisa acuta* Thunb over the rest.

(*Key words:* *Leptocorisa acuta*, bioassay of insecticides)

The rice bug *Leptocorisa acuta* Thunb (Coreidae: Hemiptera) is a major pest of rice occurring in epidemic forms sporadically. The severe infestation caused by the bug sometimes may lead to the total loss of crop (SRIVASTAVA & SAXENA, 1960; SMITH, 1981). The assessment of relative toxicity of different insecticides was undertaken in the laboratory by bio-assay in order to select the suitable insecticides for controlling the pest. The insecticides used were as their commercial formulations. Graded concentrations from the emulsifiable concentrate of the insecticides were prepared by addition of required quantities of water. The insects were taken inside petridishes and covered with wire net of 40 mesh, sprayed with one ml of the spray fluid under a Potter's tower. After drying under a fan the bugs were transferred to cylindrical jars, 20 cm × 20 cm, containing fresh rice earheads held within specimen tubes containing water. Mortality observations of the bugs were recorded after 24 hours of spraying and the data subjected to probit analysis (FINNEY, 1962) after correcting for the mortality using Abbot's formula (ABBOT, 1925).

Results presented (Table 1) show that malathion was the most highly toxic to the bug

TABLE 1. Relative toxicity of insecticides to adults of *L. acuta*.

Insecticide	Hetrogeneity	Regression equation	LC_{50}	Fiducial limits	Relative toxicity
HCH	$x^2 = 2.43$	$Y = 1.14x + 3.1609$	0.04180	0.03670 & 0.04872	1
carbaryl	$x^2 = 0.89$	$Y = 0.394x + 4.772$	0.03540	0.01853 & 0.4214	1.18
methyl parathion	$x^2 = 1.35$	$Y = 1.0357x + 4.107$	0.00729	0.005272 & 0.009350	5.74
phosalone	$x^2 = 1.46$	$Y = 0.996x + 3.491$	0.003282	0.02532 & 0.05162	1.27
fenthion	$x^2 = 1.52$	$Y = 0.937x + 4.276$	0.00592	0.004821 & 0.006781	7.06
phosphamidon	$x^2 = 1.68$	$Y = 1.392x + 3.643$	0.00952	0.007515 & 0.00994	4.39
quinalphos	$x^2 = 1.31$	$Y = 1.327x + 2.894$	0.03911	0.01911 & 0.04921	1.07
formothion	$x^2 = 0.98$	$Y = 2.9101x + 4.317$	0.00583	0.004926 & 0.00692	7.12
dimethoate	$x^2 = 1.39$	$Y = 1.325x + 3.315$	0.01864	0.01364 & 0.00281	2.24
fenitrothion	$x^2 = 2.01$	$Y = 1.424x + 3.288$	0.01603	0.01137 & 0.02137	2.61
malathion	$x^2 = 2.21$	$Y = 1.728x + 3.691$	0.00575	0.00475 & 0.00624	7.26
monocrotophos	$x^2 = 0.98$	$Y = 9.076x + 3.241$	0.01762	0.01021 & 0.02472	2.37

followed in the decreasing order by formothion, fenthion, methyl parathion, phosphamidon, fenitrothion, monocrotophos, dimethoate phosalone, carbaryl, quinalphos and HCH. Taking HCH as the standard, the insecticides carbaryl, methyl parathion, malathion, phosalone, fenthion, phosphamidon, monocrotophos, quinalphos, formothion, dimethoate and fenitrothion were 1.18, 5.74 7.26, 1.27, 7.06, 4.39, 2.37, 1.07, 7.12, 2.24 and 2.61 times as toxic as HCH to the bug respectively.

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BRIEF COMMUNICATION

OCCURRENCE OF *ODOIPORUS LONGICOLLIS* OLIVER (COLEOPTERA: CURCULIONIDAE) AS A PEST OF BANANA IN KERALA

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(*Received* 12 *November* 1988)

The banana pseudostem borer *Odoiporus longicollis* Oliver is reported from Kerala for the first time. The 'Nenthran' and 'Red Kappa' varieties of banana are found highly susceptible to the pest. The grubs tunnel within the pseudostem and the infested plants produce undersized bunches and may topple if severely damaged. The pest can be controlled by application of systemic granualar insecticides.

(*Key words:* pseudostem borer, *Odoiporus longicollis*, 'Nentharan', 'Red Kappa', systemic granular insecticides)

The banana pseudostem borer *Odoiporus longicollis* Oliver, a serious pest of banana in Bihar, West Bengal, Assam and other North Eastern States of India, is reported for the first time in Kerala. This was recorded in Vengola Panchayat of Ernakulam District in 1986. DUTT & MAITI (1972) have worked out the bionomics of the pest. The adults mate in the 'mating space' within the pseudostem and lay eggs in the air chambers through slits cut in the leaf sheaths. The emerging grubs feed on the tissues around the air chambers of the leaf sheath initially, and then bore inside the pseudostem, making extensive tunnels. As a result, the pseudo-stems rot internally and the plants become weak.

The adult weevils are black to reddish brown in colour measuring about 23–28 cm in length. The grubs are apodous and fleshy and pupation takes place within the pseudostem inside fibrous cocoons. After emergence from the cocoons, the adults come out through the square cut slits made on the pseudostem. The total life cycle is completed in about 42 days in Vellayani. The adult longivity is about 90–120 days.

The banana plants nearing bunching, with pseudostem of 25–50 cm circumference are preferred by the insect. 'Nenthran' and 'Red Kappa' varieties of banana are found more susceptible to the pest. The important symptoms of infestation are yellowing and witherring of leaves, exudation of sap from the leaf sheaths, and decaying of peduncles resulting in the immature ripening of fruits. The size of the bunch also is considerably reduced. Severely infested pseudostem may break and topple and the attached plants may contain numerous larvae, pupae and adults inside the pseudostem.

Keeping the plantation clean, planting of uninfested suckers and early detection of in-

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festation and taking timely remedial measures are methods to manage the pest in the field. Application of granular insecticide like phorate and carbofuran at 25 g/plants in the basal region was found to be effective in controlling the pest. Application of granules has to be restricted upto six months after planting only as later applications may lead to residue hazards in the fruits.

ACKNOWLEDGEMENTS

We are thankful to Dr. V. V. RAMAMURTHY, Department of Entomology, I.A.R.I., New Delhi for the identification of the insect.

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Entomon 1989 Vol. 14 No. 3 & 4 pp. 369 to 370

BRIEF COMMUNICATION

NEW RECORD OF DRYINID PARASITOID OF BROWN PLANT HOPPER, *NILAPARVATA LUGENS* STAL. AND WHITE-BACKED PLANT HOPPER, *SOGATELLA FURCIFERA* HORV.

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(*Received* 30 *January* 1989)

Four Dryinid Parasitoids viz. *Ecthrodelphax fairchildii* **Perkins,** *Haplogonatopus apicalis* **Perkins,** *Pseudogonatopus* **nr.** *pusanus* **Olmi and** *P. hospes* **Perkins were found to parasitize the rice planthoppers,** *Nilaparvata lugens* **Stal. and** *Sogatella furcifera* **Horv.**

(*Key words:* Dryinid parsaitoids, *Ecthrodelphax fairchildii*, *Haplogonatopus apicalis*, *Pseudogonatopus* nr. *pusanus*, *P. hospes*, rice brown plant hopper, white-backed plant hopper)

Consequent upon serious outbreaks of the brown plant hopper (BPH) *N. lugens* in early seventies and its rapid spread to new areas in India, considerable attention is being paid to suitable control measures, including biological control. Thirty species of nymphal and adult parasitoids (Dryinidae: Hymenoptera; Pipunculidae: Diptera; Elenchidae: Strepsiptera) have been recorded mainly on brown plant hopper and white-backed plant hopper (ANONYMOUS, 1978; MANJUNATH *et al.*, 1978a; b; CHIU, 1979; MISHRA, 1980; BENTUR & KALODE, 1985); and several insect and spider predators have also have been reported. Out of these 30 species, 13 species alone come from Dryinidae: Hymenoptera. Recently, four Dryinid species, *Ecthrodelphax fairchildii* Perkins, *Haplogonatopus* sp. (MANJUNATH, *et al.*, 1978a) *Gonatopus* sp. and *Neogonatopus* sp. (BENTUR & KALODE, 1985) on brown plant hopper and *Gonatopus* sp. (RAWAT & DIWAKAR, 1982; BENTUR & KALODE, 1985) on white-backed plant hopper have been recorded as nymphal and adult parasitoids in India.

While studying the parasitoids of the planthoppers of rice in Chhattishgargh region of Madhya Pradesh, the authors noticed four species of Dryinids parasitizing the nymphs and adults of brown plant hopper *N. lugens* and white-backed plant hopper *S. furcifera*. They were identified as *E. fairchildii*, *H. apicalis*, *P.* nr. *pusanus* and *P. hospes*.

P. nr. *pusanus* and *P. hospes* were not known previously from this country. However these have been reported from Japan and Malaysia (ANONYMOUS, 1978; CHIU, 1979). Hence it is the first record from India while other two parasitoids, *E. fairchildii* and *Haplogonatopus* sp. were earlier recorded on brown plant hopper (MANJUNATH *et al.*, 1978 a, b). Parasitization of white-backed plant hopper *S. furcifera* by *E. fairchildii* and *H. apicalis* is the new host record for these species.

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The authors are grateful to Dr. GIRISH CHANDRA of Zoology Department, Kirorimal

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College, Delhi University, Delhi for identification of the parasitoids and Dr. R. L. RAJAK, Plant Protection Adviser to the Govt. of India, Directorate of Plant Protection, Quarantine & Storage, for facilities and encouragement.

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BRIEF COMMUNICATION

DIALEUROLONGA MACULATA (SINGH) COMB. NOV. AND *DIALEUROLONGA TAKAHASHI* NOM. N. FOR *DIALEUROLONGA MACULATA* TAKAHASHI (ALEYRODIDAE : HOMOPTERA) FROM MADAGASCAR

B. VASANTHARAJ DAVID & R. W. ALEXANDER JESUDASAN[1]
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(*Received* 1 *April* 1989)

The whitefly *Aleurotulus maculata* Singh has been assigned to the genus *Dialeurolonga* Dozier. *Dialeurolonga fici* David & Subramaniam has been synonymised with *D. maculata* (Singh). A new name *Dialeurolonga takahashii* has been proposed for *Dialuerolonga maculata* described by Takahashi in 1951.

(*Key words:* whitefly, Aleyrodidae, *Dialeurolonga maculata*, *Dialeurolonga takahashii*)

During the course of study on Indian Aleyrodidae the types of *Aleurotulus maculata* Sing from the collections of the Division of Entomology, Indian Agricultural Research Institute, New Delhi were obtained on loan. A detailed study of the specimens described by Singh in 1931 from *Ficus religiosa* proved them to be assignable to the genus *Dialeurolonga* and thus a new combination *Dialeurolonga maculata* (Singh) is suggested here for *Aleurotulus maculata* Singh.

Further, a detailed study of *Dialeurolonga fici* (David and Subramaniam, 1976) from *Ficus religiosa* proved it to be the same one described by Singh (1931) under the name *Aleurotulus maculata*. Hence *Dialeurolonga fici* is considered a synonym of *D. maculata* (Singh).

A perusal of the literature indicated that Takahashi (1951) described *Dialeurolonga maculata* on *Weinmannia* sp. (Cunoniaceae) from Madagascar. Since the species described by him is distinct from that of *D. maculata* (Singh) a new name *Dialeurolonga takahashii* nom. n. is proposed for *D. maculata Takahashi*.

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Thanks are due to Dr. Swaraj Ghai and Dr. V. V. Ramamurthy, Division of Entomology, IARI, New Delhi for sparing the aleyrodid types for study.

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AUTHOR INDEX

ERRATUM

The authors write:

The inclusion of the species, *Drosophila fringifera* (appeared in the article entitled "Further records of a new and one known species of *Drosophila* from Arunachal Pradesh, India" by K. K. Gupta and J.P. Gupta, *Entomon*, 1989, Vol. 14 No. 1 & 2: 95–98) now seems to be more justified in the subgenus *Drosophila* rather than in the subgenus *Scatodrosophila*, wherein it closely resembles *D. nigriculter* Okada, but distinctly differs from it in having cercus fused with epandrium, surstylus with less number of teeth, and with distinct differences in wing-vein indices.

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